EFFECTS OF ANTI-SEIZING COMPOUNDS AND LUBRICANTS ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURES

REPORT A078 SERIAL NO. 5

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REVISED

EFFECTS OF ANTI-SEIZING COMPOUNDS AND LUBRICANTS ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURES

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MCDONNELL

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McDONNELL Aircraft Corporation
ST. LOUIS, MISSOURI

LABORATORY REPORT

SYSTEMS LABORATORY FINAL REPORT

EFFECTS OF ANTISEIZING COMPOUNDS AND LUBRICANTS ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURES

ABSTRACT

At the present time, very little information is available concerning the metallurgical effects of antiseizing compounds and lubricants on high temperature alloys at elevated temperatures. This test was conducted to gain some background information in this area.

The test was conducted in two phases. The first phase subjected seven different alloys to the effects of twenty two different compounds at a temperature of 1000F for ten hours. In the second phase, six of these alloys were subjected to twenty of the compounds at a temperature of 1800F for ten hours.

The results of the first phase of the test indicate that none of the compounds tested cause significant change in the microstructure of the alloys, observable at 250X, for temperatures up to 1000F. At 1800F, however, considerable corrosion was present. The type and degree of corrosion varied with the different compounds and alloys.

From the results of this test, it could be assumed that any of the compounds tested would be satisfactory for use on these alloys at temperatures to 1000F, but care should be used in selecting an alloy-compound combination for use in the higher temperature range. It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antiseizing, lubricating, or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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1. INTRODUCTION

A number of antiseizing compounds, lubricants, and binders are now in use or being studied for use, at McDonnell. Very little information is available concerning the metallurgical effects of these compounds on high temperature alloys at elevated temperatures. The intent of this report is to furnish information in this field.

The information contained in this report is based on the results of tests conducted during the period 1 June 1961 through 18 July 1961, by the Methods Test Group, Systems Laboratory, General Engineering Division of McDonnell Aircraft.

The testing was carried out in two phases. In phase one, sets of seven specimens, of different alloys, were placed in twenty three containers containing different compounds. After this the containers were taken to a temperature of 1000F and held there for ten hours. In phase two, specimens of six of the above alloys were subjected to twenty one of the above compounds and 1800F for ten hours.

It should be noted that this report deals only with the metallurgical effects of the compounds tested, and no reference will be made to the antiseizing, lubricating, or binding capabilities of the compounds. A future series of test are now being considered for obtaining this information.

2. DESCRIPTION OF TEST ARTICLES

Seven different alloys and twenty two different compounds were tested, (one container in each of the two phases contained only the specimens and ambient air) they are as follows:

2.1 Alloys

(A) Inconel X: 0.04C, 0.7 Mn, 0.5 Si, 15 Cr, 75 Ni, 1Cb, 2.5 Ti, 0.9 Al, 7 Fe.

(B) A-286: 0.08C, 1.35 Mn, 0.5 Si, 15 Cr, 25 Ni, 1.25 Mo, 2 Ti, 0.25 Al, 0.3 V, remainder Fe.

(C) Rene'41: 0.1C, 19 Cr, 11 Co, 10 Mo, 3 Ti, 1.5 Al, 5 Fe, Trace B, Remainder Ni.

(D) L-605: 0.15C, 1.5 Mn, 0.5 Si, 20 Cr, 10 Ni, 15 W, 2 Fe, Remainder Co.

(E) Hastelloy X: 0.15C, 22 Cr, 9 Mo, 20 Fe, Remainder Ni.

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2.1 Alloys (cont'd.)

(F) 310 S.S.: 0.25 C, 2 Mn, 1.5 Si, 25 Cr, 20 Ni, Remainder Fe.

(G) 4130 STL: (1000F phase only) 0.3C, 0.5 Mn, 0.04 P, 0.04S, 0.3 Si, 1 Cr, 0.2 Mo, Remainder Fe.

NOTE: The above figures are approximate percentages of the elements present in the alloys; therefore, they may not add up to 100%.

2.2 Compounds

(A) Silver Goop: (Anticeizing Compound) Manufactured by Crawford Fitting Company, Cleveland, Ohio. A metallic, fluid, paste, designed for use on high temperature alloys, at temperatures up to 2000F. Composition: aluminum oxide (Al_2O_3), graphite, magnesium oxide (MgO), silver and silica (SiO_2).

(B) Crane 425A: (Anticeizing Compound) Manufactured by Crane Plumbing Supply Company, St. Louis, Missouri. A thick, brown paste, designed for use at temperatures to 1050F. Composition: Information not released by vendor. (Used in 1000F phase only.)

(C) Base Off 990: (Anticeizing Compound) Manufactured by the Texicone Company, Dallas, Texas. A thick brown paste, designed for use at temperatures to 1800F. Composition: molybdenum disulfide (MoS_2), lead oxide PbO), and graphite.

(D) Fel-Pro C5A: (Anticeizing Compound) Manufactured by Felt Products Manufacturing Company, Skokie, Illinois. A thick metallic paste, designed for use at temperatures to 1800F. Composition: colloidal copper base.

(E) DCF 123: (Lubricant) Manufactured by Miracle Power Products Corporation, Cleveland, Ohio. A black aerosol spray. Composition: graphite.

(F) MIL-T-5544-A: (Anticeizing Compound) The compound tested was manufactured by Fermatex Company, Incorporated, Kansas City, Kansas. A thick, black paste, designed for use at temperatures to 1200F. Composition: 50% graphite and 50% petrolatum.

(G) Electrofilm 1000: (Lubricant) - Compound manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 1500F. Composition: graphite and lead oxide (PbO).

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2.2 Compounds (cont'd.)

(H) Electrofilm 1005: (Lubricant) Compound manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 700F in air (to 2000F in vacuum). Composition: molybdenum disulfide (MoS_2).

(I) Electrofilm 2006: (Antiseizing Compound) Compound manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin black electrically bonded film, designed for use at temperatures to 800F in air (to 2000F in vacuum). Composition: graphite.

(J) Electrofilm 660: (Antiseizing Compound) Compound manufactured and applied by Dynacraft Corporation, St. Louis, Missouri. A thin, black, electrically bonded film, designed for use at temperatures to 600F in air (to 2000F in vacuum). Composition: molybdenum disulfide (MoS_2) and graphite.

(K) Phosphatherm M: (Antiseizing Compound) Manufactured by The Alpha Molykote Corporation, Stamford, Connecticut. A coarse, pink, powder designed for use at temperatures to 2200F. Composition: potassium, sodium, and phosphorus pentoxide (P_2O_5).

(L) Molykote X-106M: (Lubricant) Manufactured by The Alpha Molykote Corporation, Stamford, Connecticut. A thin, black, metallic, liquid, designed for use at temperatures to 700F in air (to 2000F in vacuum.) Composition: molybdenum disulfide (MoS_2) (Used in 1000F phase only.)

(M) Molykote X-106: (Lubricant) Same as Molykote X-106M with the exception of the material used as a binder.

NOTE: The materials listed under composition for the above commercial compounds are only the basic components. Complete information on the composition of these compounds is, in most cases, unavailable.

(N) Sodium Silicate: (Binder) A thick, clear, liquid (Na_2SiO_3)

(O) Silica: (Binder) A fine, white powder. (SiO_2); A.C.S. pure grade.

(P) Milk of Magnesia (Anticeizing Compound) A thick white liquid. $Mg(OH)_2$; U.S.P. grade

(Q) Magnesium Oxide: (Anticeizing Compound) A fine white powder. (MgO); A.C.S. reagent grade.

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2.2 Compounds (Cont'd.) FINAL REPORT

(R) Boron Nitride: (Antiseizing Compound). A fine white powder. (BN); commercial grade.

(S) Boric Oxide: (Binder) A fine white granular compound. (B_2O_3); A.C.S. reagent grade.

(T) Lead Monoxide: (Lubricant) A fine, yellow, powder. (PbO): N.F. IX grade.

(U) Calcium Fluoride: (Lubricant) A fine, white powder (CaF_2): A.C.S. reagent grade.

(V) Lead Sulfide: (Lubricant) A coarse, black powder. (PbS); A.C.S. reagent grade.

3. TEST SETUP

Containers for the specimens and compounds were fabricated from 301 S.S. sheet and tube stock. Materials for specimens were obtained and machined, when required, and cut to the required dimensions (see Figure A page 9).

For the 1000F phase of the test sets of seven specimens, one of each material type (see Description of Test Articles, Alloys, page 2) were placed in twenty three different containers. The specimens were suspended on stainless steel wire and separated by ceramic bead spacers so the specimens could not come into contact with each other or the containers. White sand, which was used as a seal to retard the circulation of air into the containers, was added to the outer area of the container. Then the inner area of the containers, which contained the specimens, was blown clean with high pressure air, to remove foreign particles, in preparation for the addition of the compounds and high temperature exposure. (See Figure B , page 10).

For the 1800F phase of the test, the same containers were cleaned and reused for their respective compounds. The specimens were placed in their containers in the same manner as for the 1000F phase, except there were only six specimens in each set due to the fact that the 4130 steel specimens were omitted because of the temperature limitations of this material. Also, only twenty one containers were used because two compounds were omitted. One (Grease 425A) was omitted because of temperature limitations, and the other (Molykote X-106A) because of not being available at the time of test.

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4. TEST PROCEDURE

All compounds tested, with the exception of the Electrofilm series, which were electrically bonded to the specimens by Dynacraft Corporation, St. Louis, Missouri, were added to the containers after the specimens were mounted in them. The containers were then placed in an air atmosphere furnace, in the Materials and Methods Laboratory, and held at 300F for approximately one hour to drive off volatile substances. The lids were then placed on the containers and they were subjected to high temperature exposure.

For the 1000F phase of the test, the twenty-three containers; twenty two contained the various compounds, see "Description of Test Articles, Compounds", page 3) and one, for control specimens, containing ambient air; were placed in an air atmosphere furnace. Then the specimens were heated to a temperature of 1000F and held at this temperature for ten hours, and allowed to air cool to room temperature. The specimens were then removed from the containers, and the containers were cleaned in preparation for use in the 1800F phase of the test.

For the 1800F phase, the twenty one containers; twenty containing the compounds to be tested (see Description of Test Articles, Compounds" page 3) and one, for control specimens, containing ambient air; were placed in an air atmosphere furnace and heated to a temperature of 1800F, held at this temperature for ten hours and allowed to air cool to room temperature. After this, they were removed from the containers to be mounted and polished.

A transverse and longitudinal sample were cut from each specimen. These were mounted in a clear plastic (Epon 828 resin, using diethylene triamine for catalyst). After this, the samples were ground and polished for metallographic examination. The samples from the 1000F exposure were then etched and photomicrographs taken of the transverse samples. Photomicrographs were obtained prior and subsequent to the 1800F exposure tests.

5. TEST RESULTS

The photomicrographs of the transverse samples from the 1000F exposure show that the compounds tested caused no significant change in the microstructure of the alloys exposed (see Figures 1 through 161) pages 12 through 65.

The photomicrographs of the 1800F exposure samples (see Figures 162 through 415, pages 66 through 195) show a wide variety of effects, ranging from no attack to very severe corrosive action (see Table 1, page 8).

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5. TEST RESULTS (Cont'd.)

The results of this phase of the test show that several of the compounds tested would be unsatisfactory for use in this temperature range.

6. DISCUSSION OF TEST RESULTS

The results of the 1800F phase of this test, indicate that three of the compounds tested caused no significant corrosive attack (i.e. the corrosion present was of the same type and did not exceed the rate of corrosion of the control specimens, which were exposed to only air) to any of the alloys tested, for temperatures up to 1800F. These three compounds, Fel-Pro C5-A, Boron Nitride, and Milk of Magnesia, were the least corrosive. At the other end of the scale was Ease-Off 990, Phosphatherm RE, Molykote X-106, and lead sulfide. These four compounds severely attacked all the alloys tested. The corrosive action of the other 13 compounds tested to 1800F varied within the range of these two extremes. Some of these compounds attacked a few of the alloys while leaving the others untouched, and some of them slightly attacked all the alloys. The remainder of the compounds displayed a combination of both of these vices by slightly attacking some alloys and severely attacking others.

These results indicate that certain facts, such as the alloy the compound is to be used on and the amount of corrosion allowable, should be taken into consideration before these compounds are used.

Another factor to be considered is the temperature at which the compounds are used. Since the temperature spread between 1000F, where no corrosion was observed, and 1800F, where considerable corrosion was observed, is quite large, the results here are not too conclusive.

7. CONCLUSIONS

The fact that no significant amount of attack was present on the specimens subjected to the 1000F phase of this test, indicates that all the compounds tested would be satisfactory for use up to this temperature.

The amount of corrosion present on the specimens subjected to the 1800F phase of this test shows that care should be taken in selecting a compound for use in this temperature range.

It should be noted that this report deals only with the metallurgical effects of the compounds tested on metals in the unstressed condition and no reference will be made to the antiseizing, lubricating or binding capabilities of the compounds. A future series of tests are now being considered for obtaining this information.

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TABLE 1

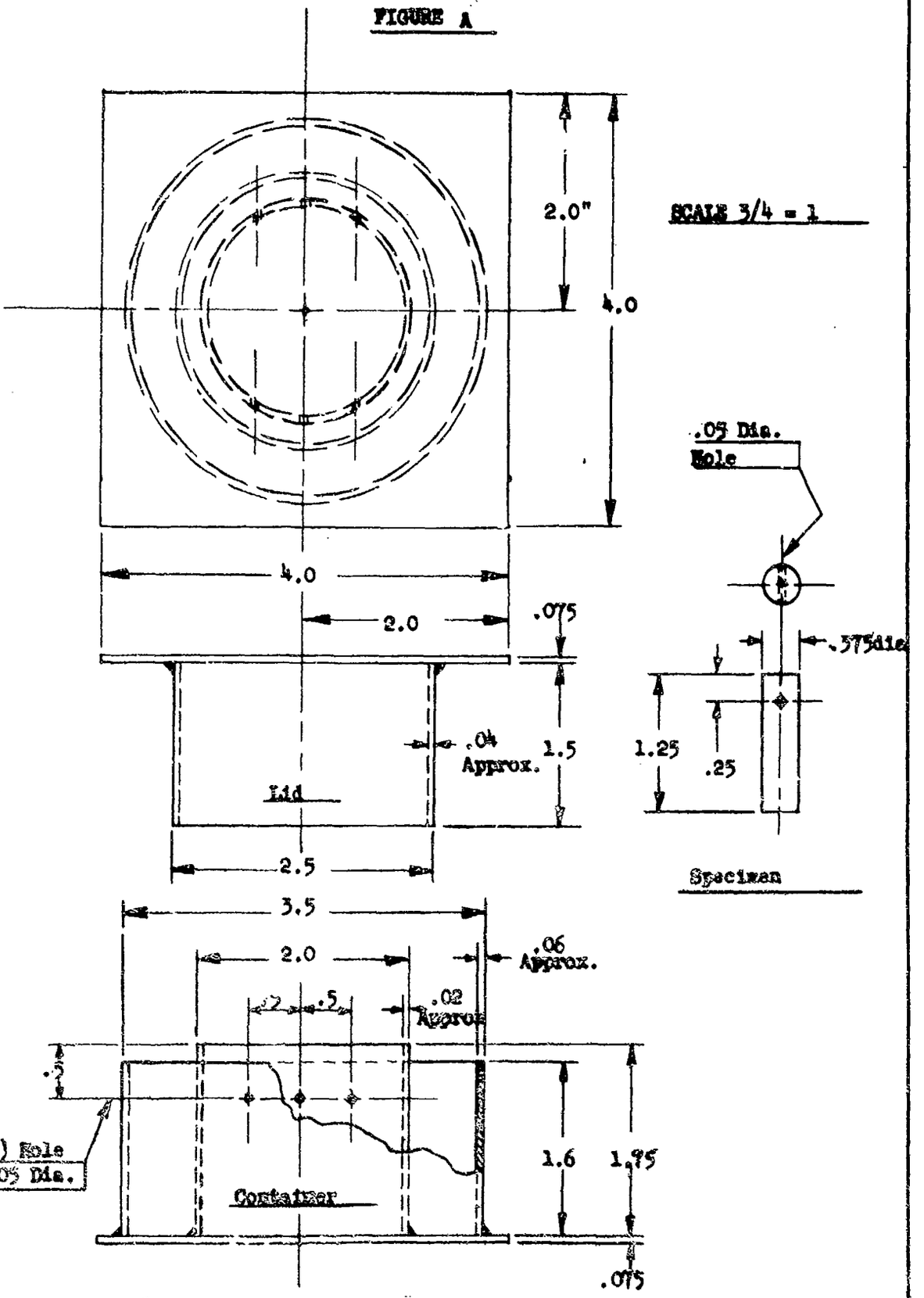
CORROSIVE EFFECTS OF COMPOUNDS ON ALLOYS AT 1800°F

	Inconel X	A-286	Rene'41	L-605	Hastelloy X	310 S. S.
Silver Goop	Good	Good	Fair	Good	Good	Poor
Base Off 990	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor
Fel-Pro 65-A	Good	Good	Good	Good	Good	Good
DOF 123	Good	Fair	Good	Good	Fair	Good
MIL-T-5544-A	Fair	Good	Fair	Fair	Good	Poor
Electrofilm 1000	Fair	Fair	Good	Fair	Fair	Poor
Electrofilm 1005	Poor	Good	Fair	Fair	Fair	Poor
Electrofilm 2007	Fair	Fair	Fair	Fair	Poor	Poor
Electrofilm 66C	Fair	Good	Fair	Fair	Poor	Fair
Phosphatherm RM	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor
Sodium Silicate	Fair	Good	Fair	Poor	Fair	Fair
Silica	Good	Good	Poor	Good	Good	Good
Milk of Magnesia	Good	Good	Good	Good	Good	Fair
Magnesium Oxide	Fair	Good	Poor	Poor	Poor	Good
Boron Nitride	Good	Good	Good	Good	Good	Good
Boric Oxide	Fair	Good	Good	Good	Poor	Poor
Molykote X-106	V. Poor	V. Poor	V. Poor	Poor	V. Poor	V. Poor
Lead Monoxide	Poor	Fair	Poor	Poor	Poor	Poor
Calcium Fluoride	Good	Good	Good	Poor	Poor	Fair
Lead Sulfide	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor	V. Poor

EXPLANATION OF DESIGNATIONS

Good	Fair	Poor	V. Poor
Corrosion is of same type and doesn't exceed rate of control specimens (in air).	Corrosion slightly exceeds and/or is of a different type than control.	Considerable amount of corrosion is present.	Severe corrosive attack is evident.

FIGURE A



TYPICAL CONFIGURATION OF CONTAINER, LID, AND SPECIMEN

ASSEMBLY OF SPECIMENS FOR TESTING ANTI-SEIZE COMPOUNDS T.R. 513-218

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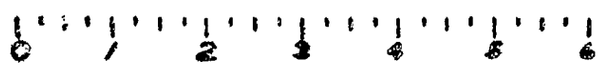
NOTE

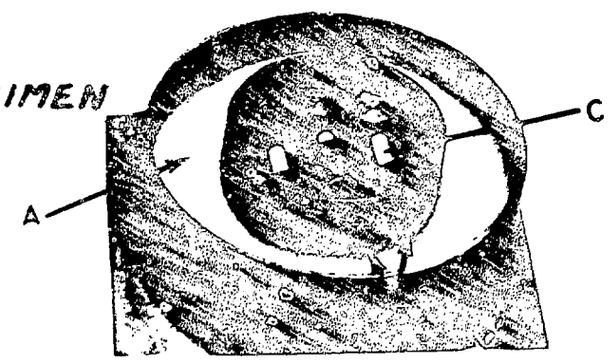
A. WHITE SAND
B. STAINLESS STEEL WIRE
C. CERAMIC BEADS



SCALE IN INCHES

TYPICAL SPECIMEN

CONTAINER LID



SPECIMENS IN CONTAINER

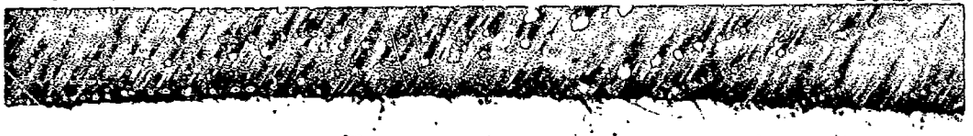
TABLE 2

EXPLANATION OF ETCHANT CODES

Etchant Code	Common Name	Composition	Alloys Used On
A	Marbles	20g $CuSO_4$ 100 ml HCl 100 ml water	Inconel X
B	- - - -	1 ml HNO_3 3 ml HCl 3 ml glycerine	A-286
C	Hydrochloric Peroxide	HCl 30% H_2O_2 added by drops as needed.	René'41 L-605 Hastelloy X
D	10% Oxalic	1 ml $H_2C_2O_4$ 9 ml water (electrolytic)	310 S.S.
E	Picral	4g $C_6H_3O_7N_3$ 100 ml C_2H_5OH	4130 Steel
U	- - -	Unetched - - -	

M 4555 Silver Goop On Inconel X Figure 1
Mag: 250X 1000°F Etch: A

M 4556 Silver Goop on A-286 Figure 2
Mag: 250X 1000°F Etch: B

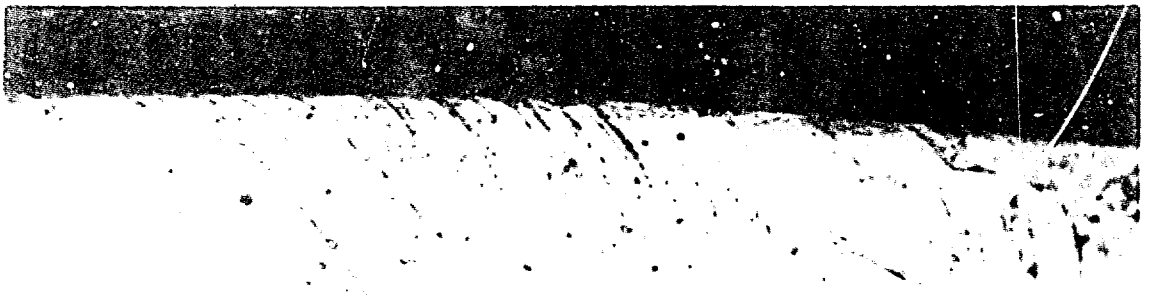


M 4557 Silver Goop on René 41 Figure 3
Mag: 250X 1000°F Etch: C

M 4558
Mag: 250X

Silver Coop on L-605
1000°F

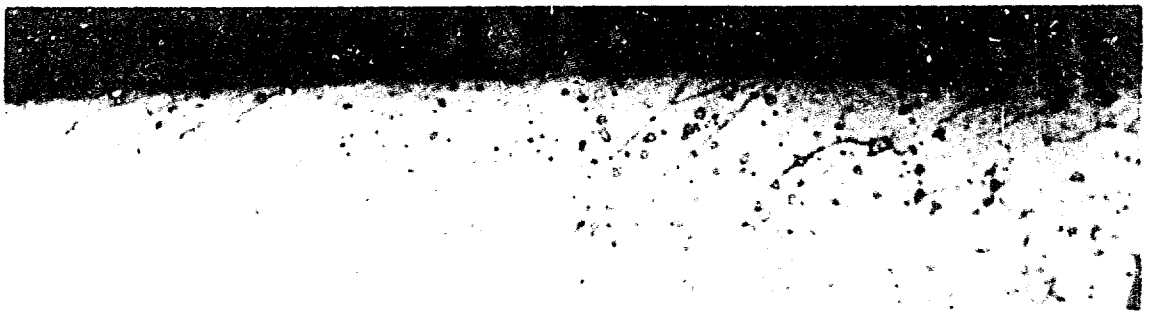
Figure 4
Etch: C



M 4559
Mag: 250X

Silver Coop on Hastelloy X
1000°F

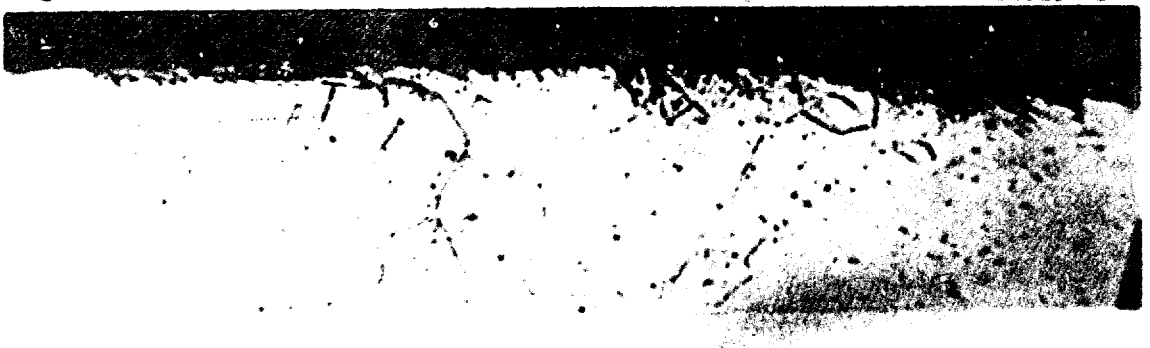
Figure 5
Etch: C



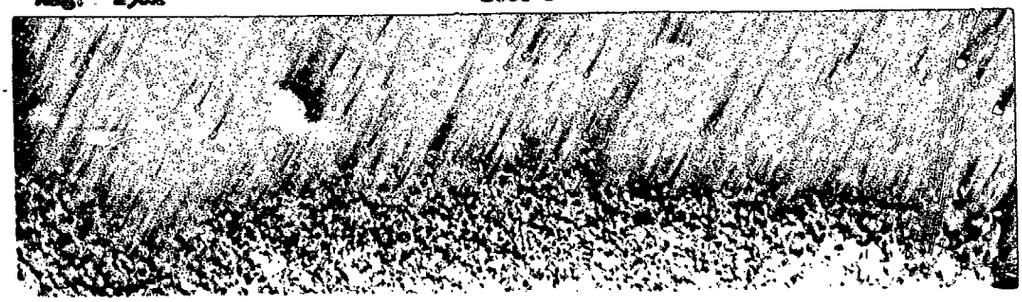
M 4560
Mag: 250X

Silver Coop on 310 SS
1000°F

Figure 6
Etch: D



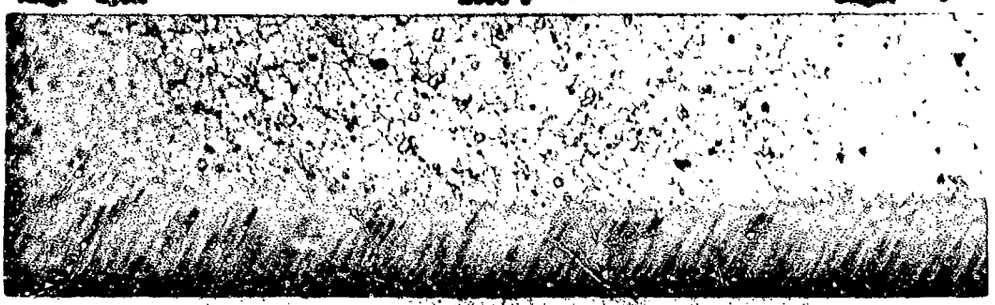
M 4561 — Silver Goop on 4130 Steel — Figure 7
Mag: 250X — 1000°F — Etch: E



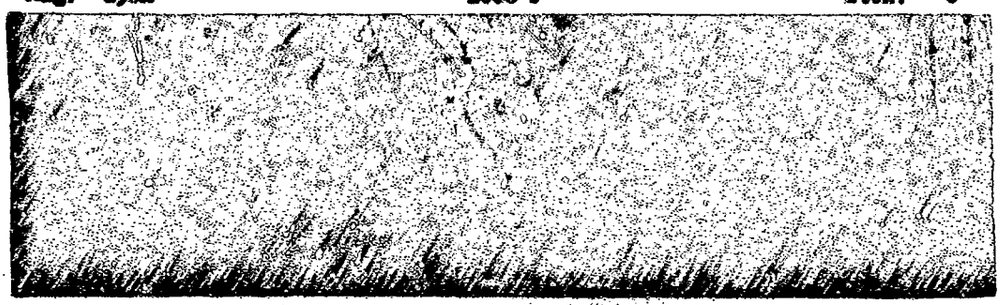
M 4562 — Crane 425A on Inconel X — Figure 8
Mag: 250X — 1000°F — Etch: A

M 4563 — Crane 425A on A-286 — Figure 9
Mag: 250X — 1000°F — Etch: B

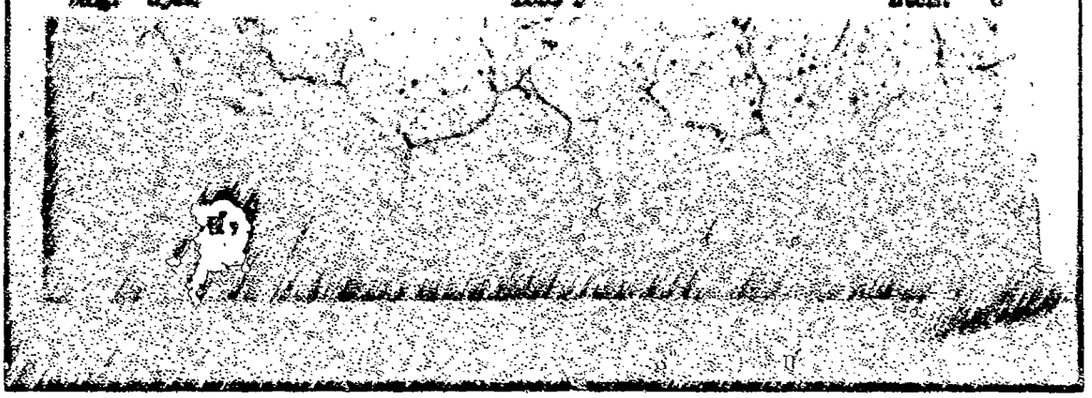
M 4594 Crane 4092A on Rene 41 Figure 10
Mag: 250X 1000°F Etch: C



M 4593 Crane 4092A on L-605 Figure 11
Mag: 250X 1000°F Etch: C

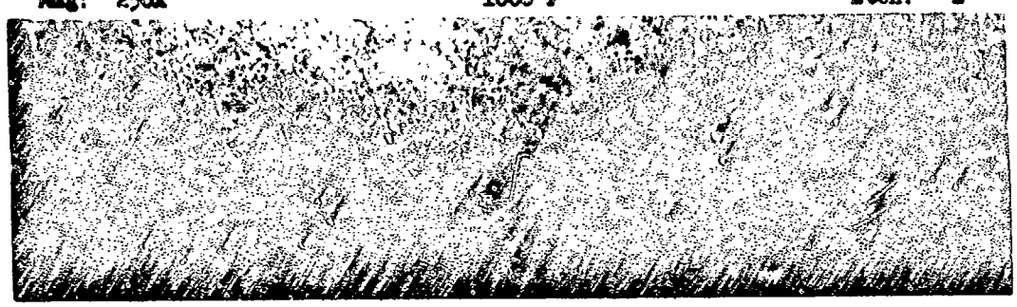


M 4592 Crane 4092A on Haynes X Figure 12
Mag: 250X 1000°F Etch: C

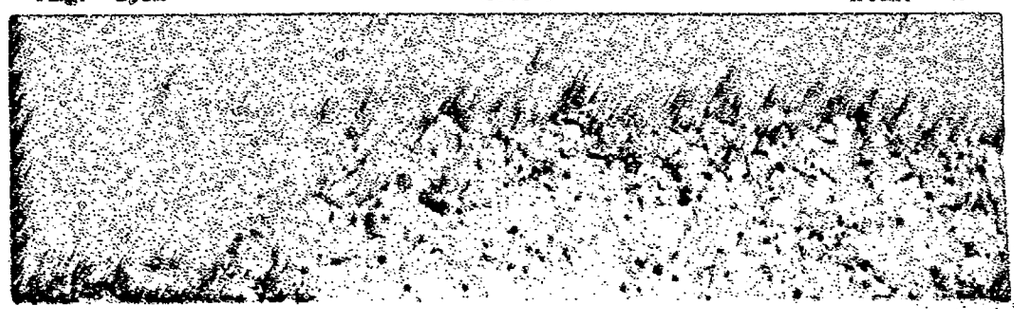


M 4567 Crane 425A on 310 SS Figure 13
Mag: 250X 1000°F Etch: D

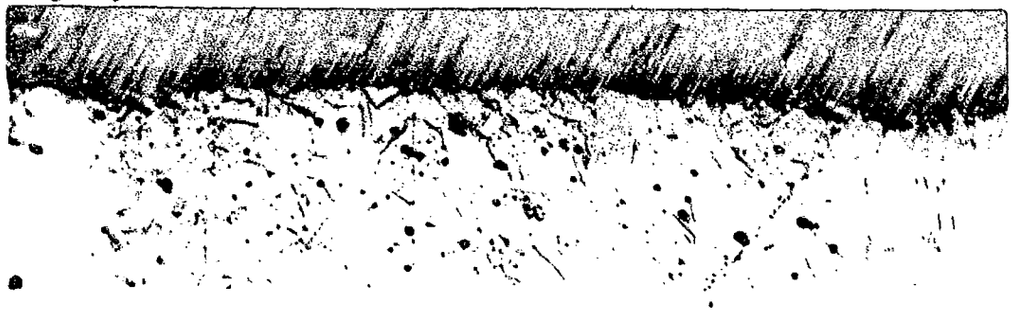
M 4568 Crane 425A on 4130 Steel Figure 14
Mag: 250X 1000°F Etch: E



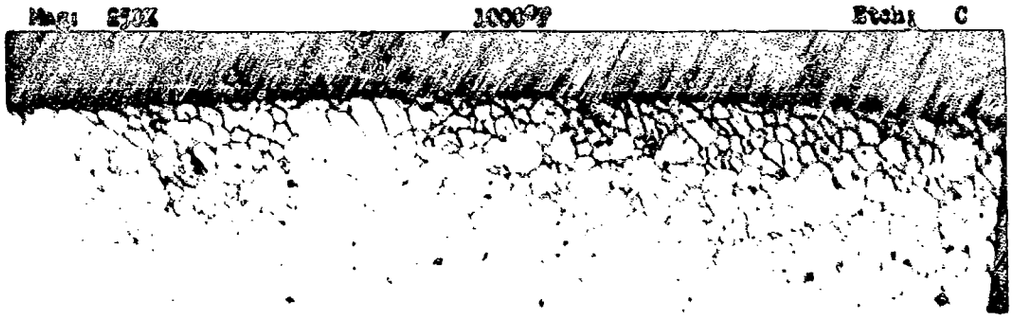
M 4569 Haze Off 990 on Inconel X Figure 15
Mag: 250X 1000°F Etch: A



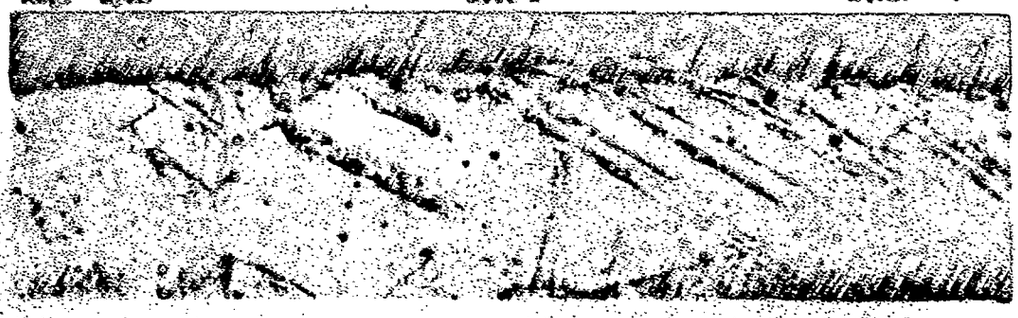
N 4570 Base Off 990 on A-286 Figure 16
Mag: 250X 1000°F Etch: B



N 4571 Base Off 990 on Haynes 41 Figure 17
Mag: 250X 1000°F Etch: C

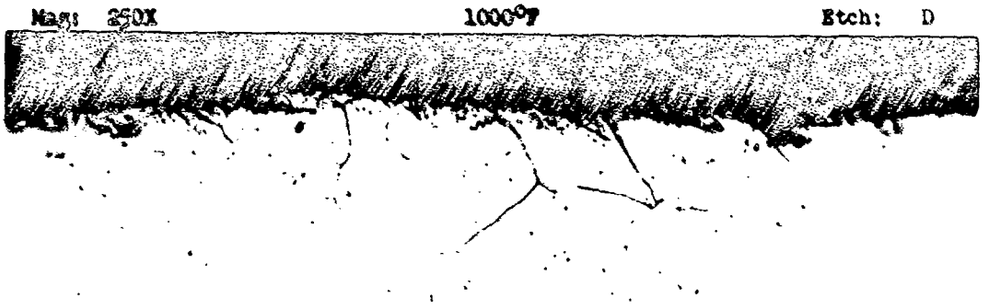


N 4572 Base Off 990 on L-605 Figure 18
Mag: 250X 1000°F Etch: C



M 4573 — Base Off 990 on Rastelloy X — Figure 19
Mag: 250X — 1000°F — Etch: C

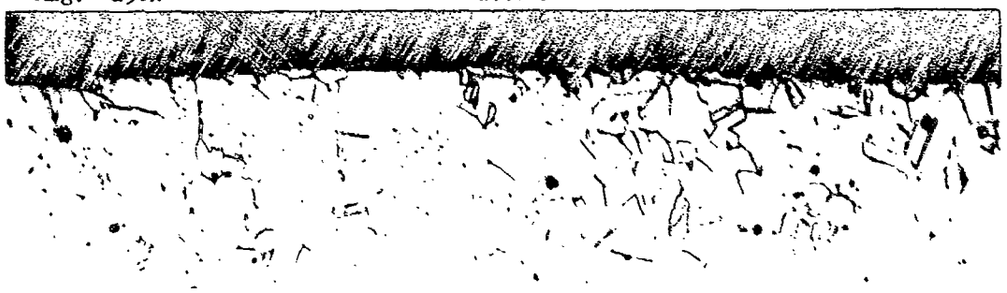
M 4574 — Base Off 990 on 310 SS — Figure 20
Mag: 250X — 1000°F — Etch: D



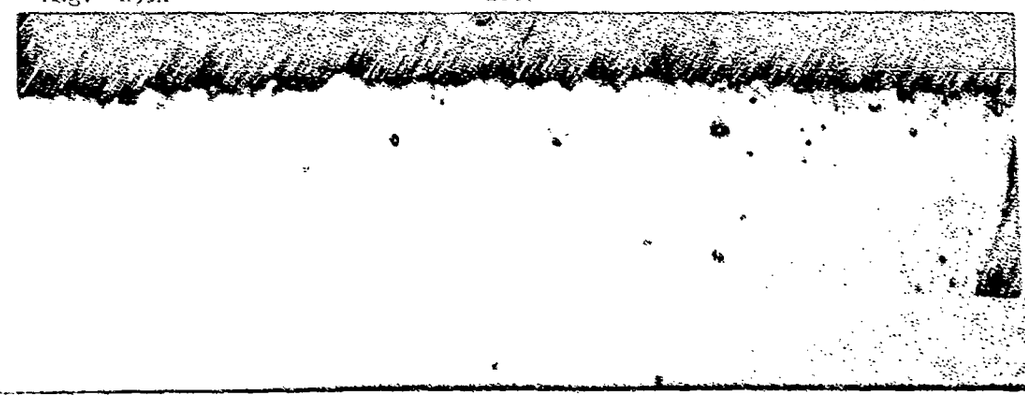
M 4575 — Base Off 990 on 4130 Steel — Figure 21
Mag: 250X — 1000°F — Etch: E

M 4576 Fel-Pro 65-A on Inconel X Figure 22
Mag: 250X 1000°F Etch: A

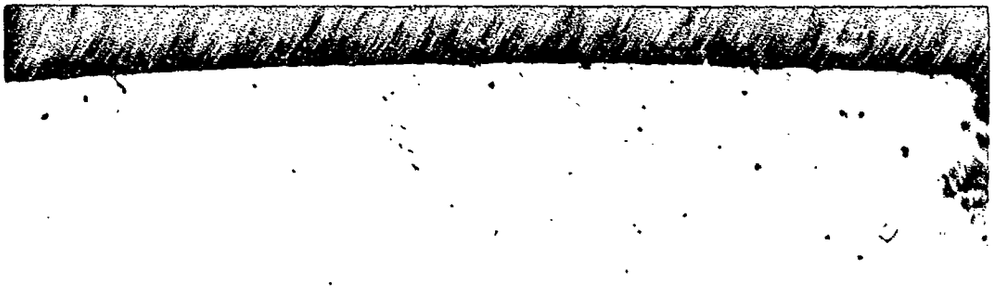
M 4577 Fel-Pro 65-A on A-286 Figure 23
Mag: 250X 1000°F Etch: B



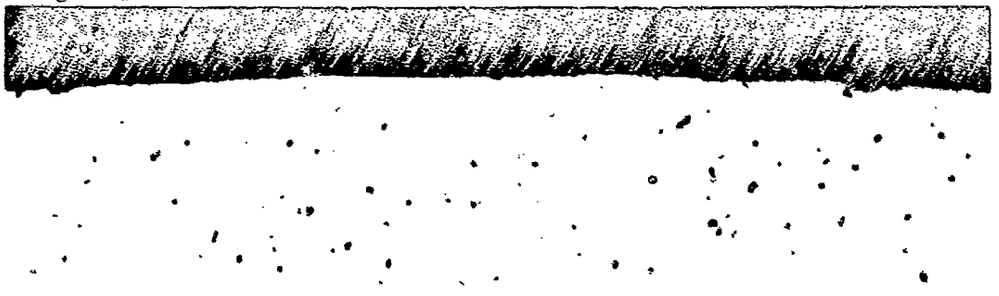
M 4578 Fel-Pro 65-A on René 41 Figure 24
Mag: 250X 1000°F Etch: C



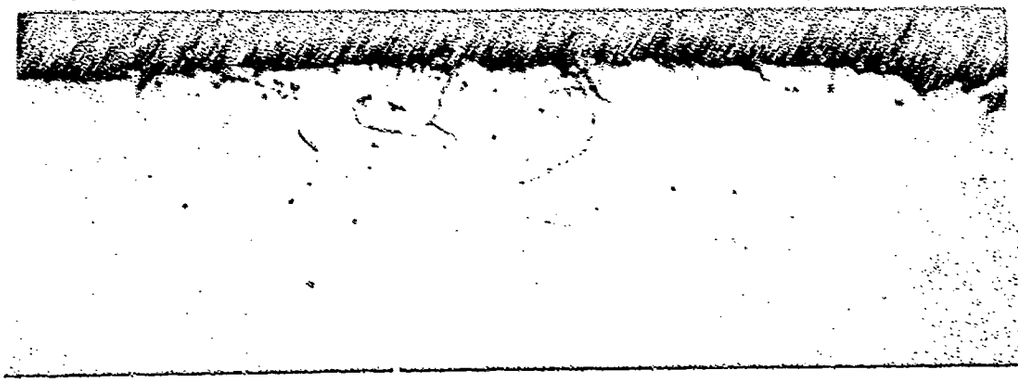
M 4579 Fel-Pro 65-A on L-605 Figure 25
Mag: 250X 1000°F Etch: C



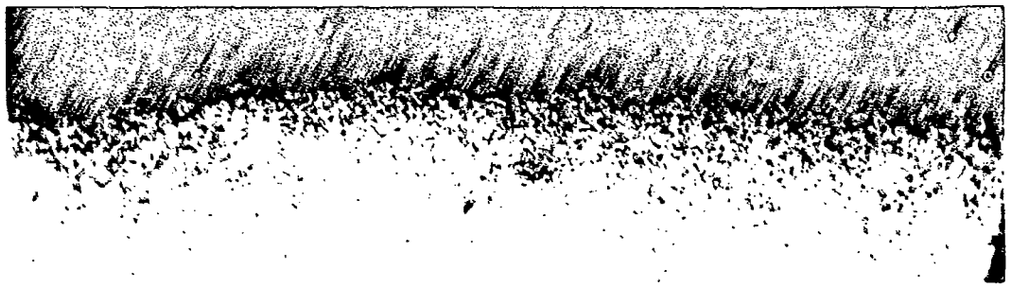
M 4580 Fel-Pro 65-A on Hastelloy X Figure 26
Mag: 250X 1000°F Etch: C



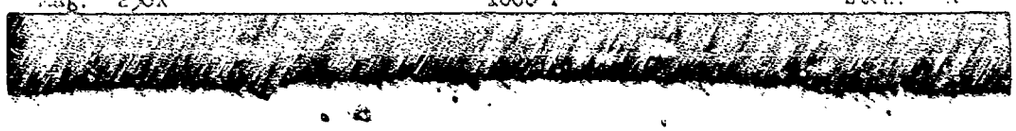
M 4581 Fel-Pro 65-A on 310 SS Figure [illegible]
Mag: 250X 1000°F Etch: [illegible]



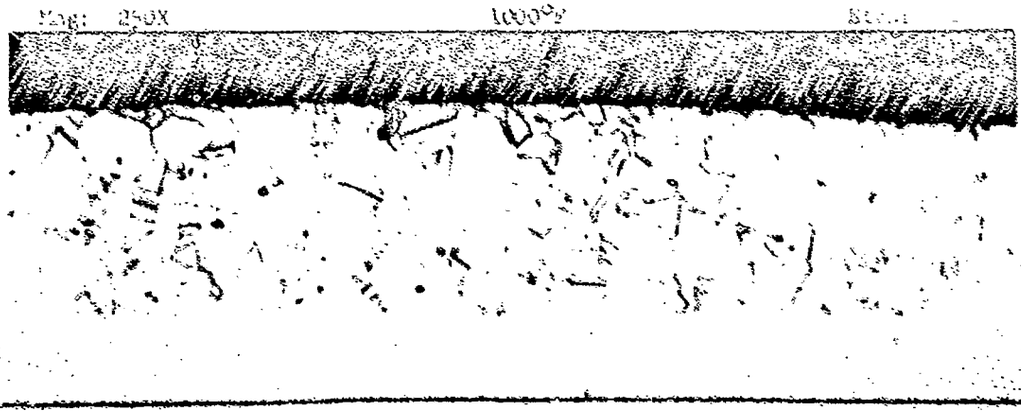
M 4582 Fel-Pro 65-A on 4130 Steel Figure 28
Mag: 250X 1000°F Etch: E



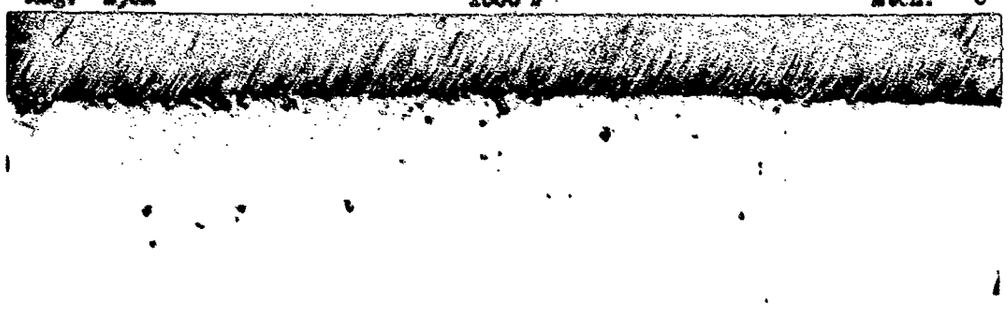
M 4583 DGF-123 on Inconel X Figure
Mag: 250X 1000°F Etch:



M 4584 DGF-123 on A-286 Figure
Mag: 250X 1000°F Etch:

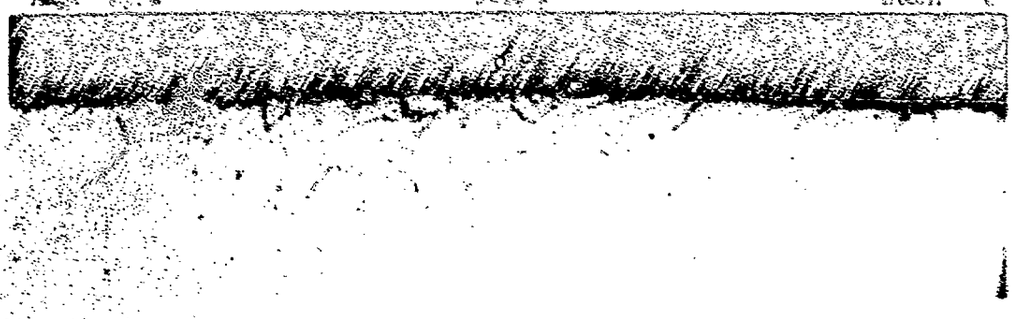


M 4585 DCP-123 on Rene 41 Figure 31
Mag: 250X 1000°F Etch: C



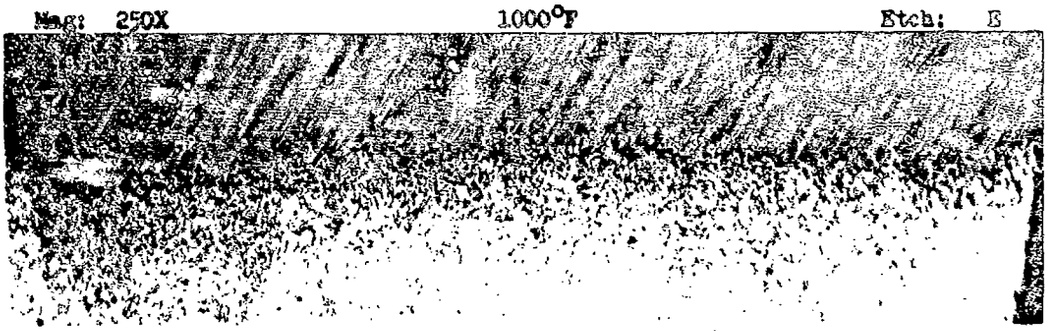
M 4586 DCP-123 on L-605 Figure 32
Mag: 250X 1000°F Etch: C

M 4587 DCP-123 on Hastelloy X Figure 33
Mag: 250X 1000°F Etch: C

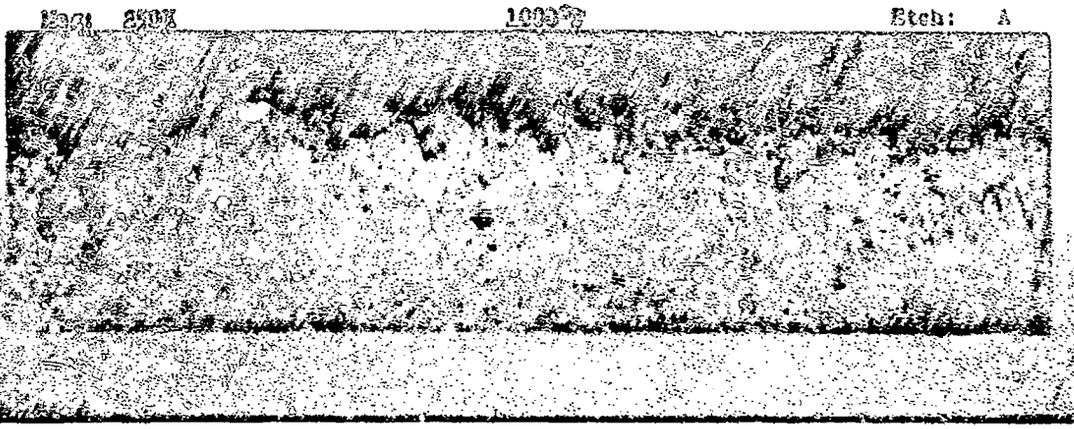


M 4588 DOF-123 on 310 SS Figure 34
Mag: 250X 1000°F Etch: D

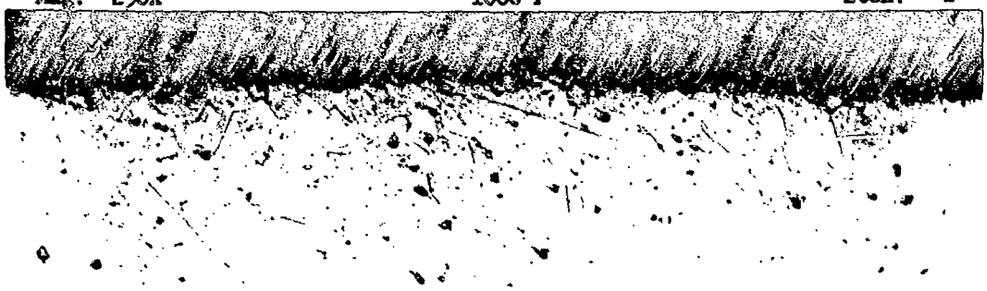
M 4589 DOF-123 on 4130 Steel Figure 35
Mag: 250X 1000°F Etch: E



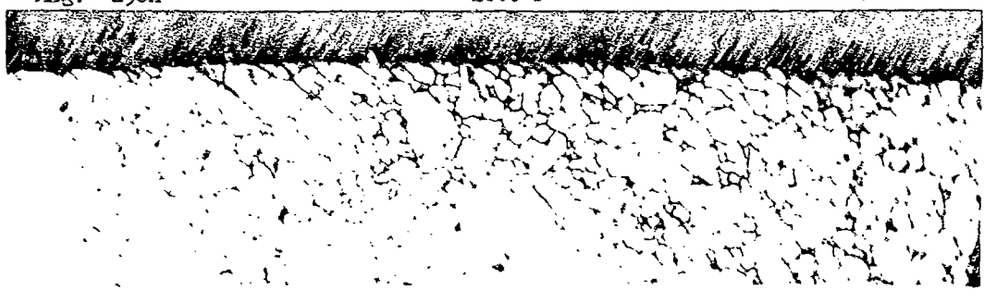
M 4590 MIL-C-5544 on Inconel X Figure 36
Mag: 250X 1000°F Etch: A



M 4591 MIL-C-5544 on A-286 Figure 37
Mag: 250X 1000°F Etch: B



M 4592 MIL-C-5544 on René 41 Figure 38
Mag: 250X 1000°F Etch: C

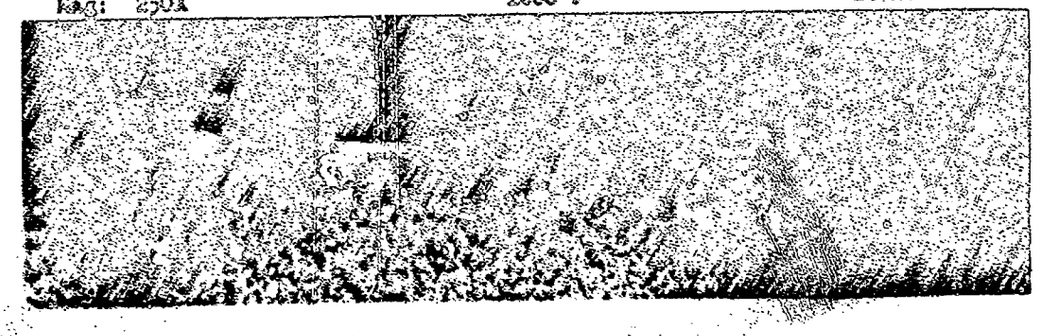


M 4593 MIL-C-5544 on L-605 Figure 39
Mag: 250X 1000°F Etch: C

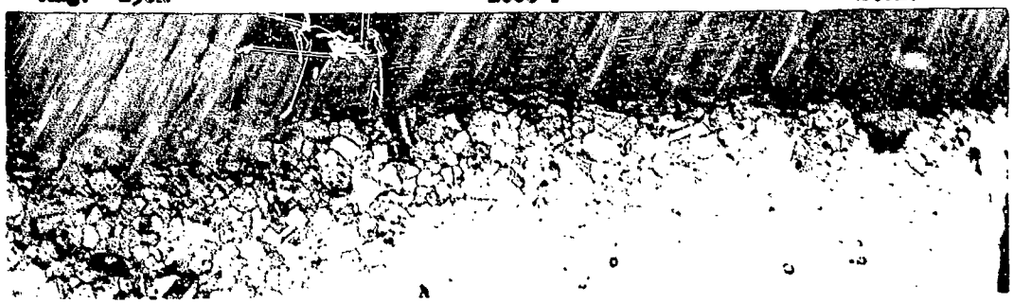
M 4594 MIL-C-5544 on Hastelloy X Figure 40
Mag: 250X 1000°F Etch: C

M 4595 MIL-C-5544 on 310 SS Figure 41
Mag: 250X 1000°F Etch: D

M 4596 MIL-C-5544 on 4130 Steel Figure 42
Mag: 250X 1000°F Etch: E

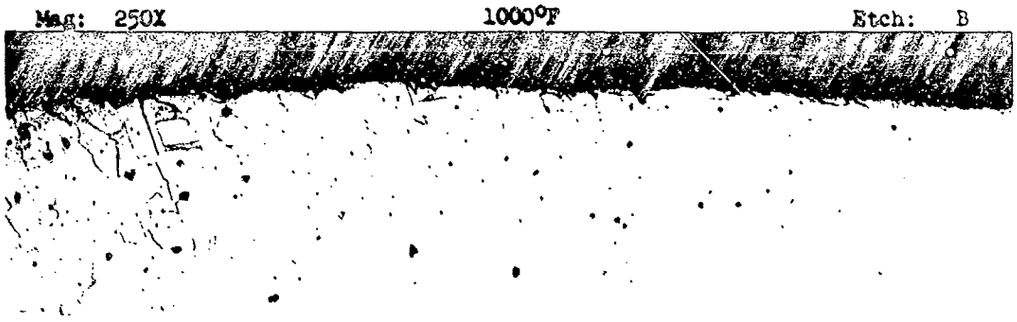


M 4597 Electrofilm 1000 on Inconel X Figure 43
Mag: 250X 1000°F Etch: A

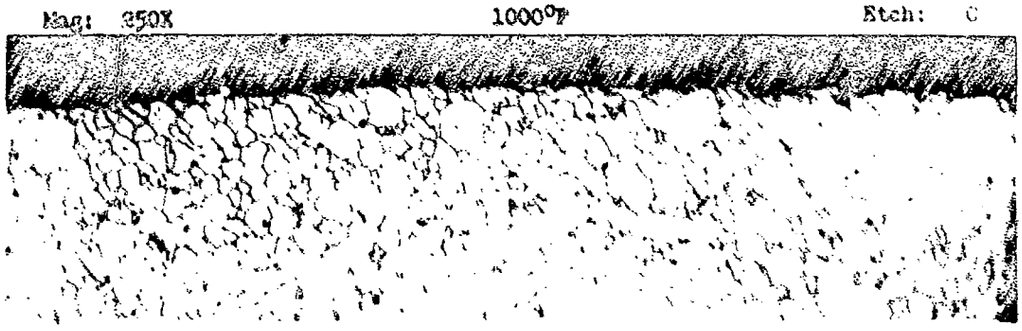


A

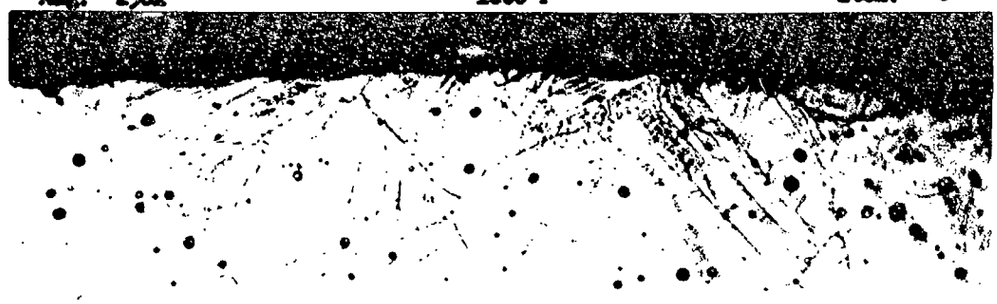
M 4598 Electrofilm 1000 on A-286 Figure 44
Mag: 250X 1000°F Etch: B



M 4599 Electrofilm 1000 on René '41 Figure 45
Mag: 250X 1000°F Etch: C

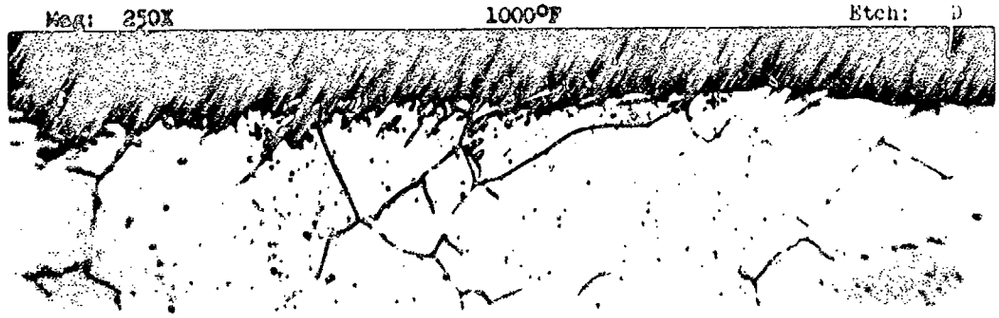


M 4600 Electrofilm 1000 on L-605 Figure 46
Mag: 250X 1000°F Etch: C

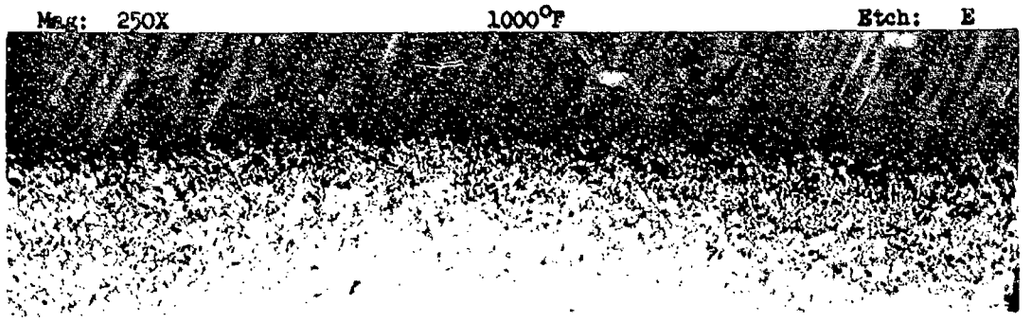


M 4601 Electrofilm 1000 on Hastelloy X Figure 47
Mag: 250X 1000°F Etch: C

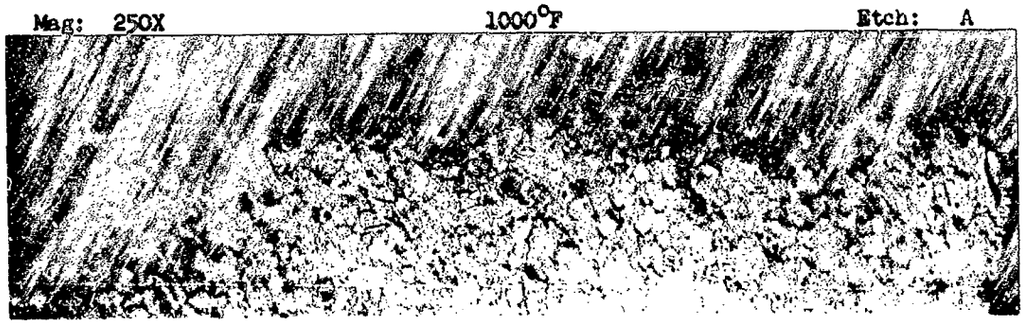
M 4602 Electrofilm 1000 on 310 SS Figure
Mag: 250X 1000°F Etch: D



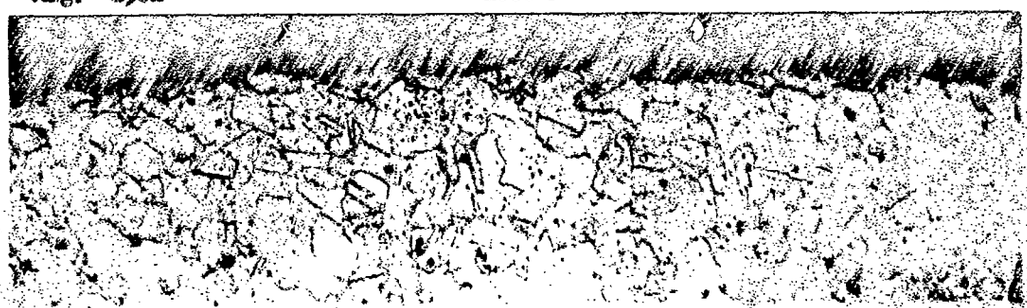
M 4603 Electrofilm 1000 on 4130 Steel Figure 49
Mag: 250X 1000°F Etch: E



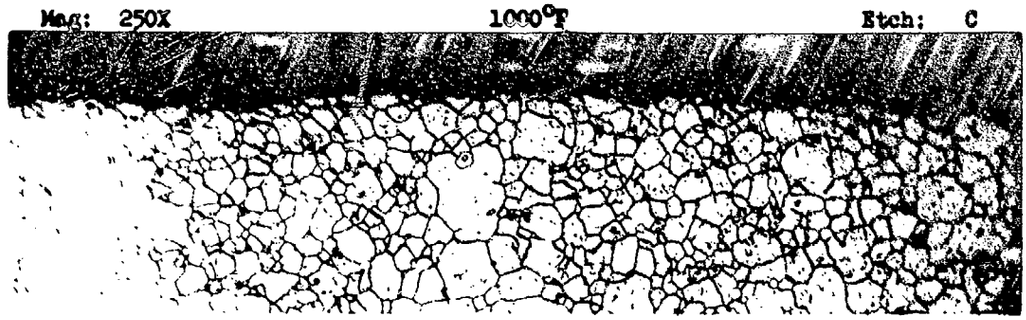
M 4604 Electrofilm 1005 on Inconel X Figure 50
Mag: 250X 1000°F Etch: A



M 4605 Electrofilm 1005 on A-286 Figure 51
Mag: 250X 1000°F Etch: B

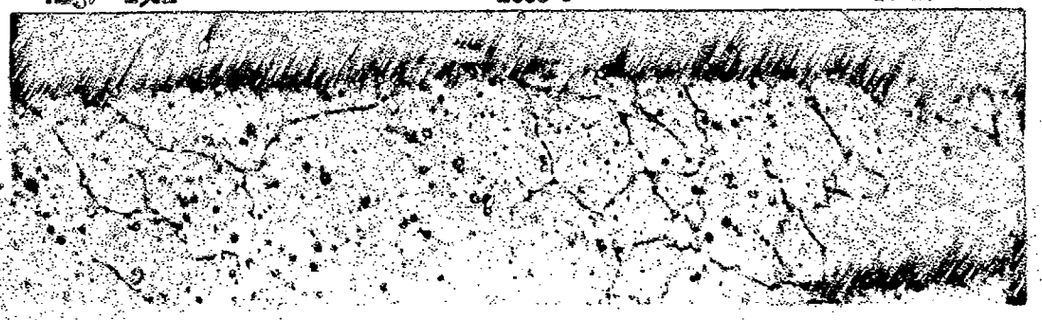


M 4606 Electrofilm 1005 on René 41 Figure 52
Mag: 250X 1000°F Etch: C

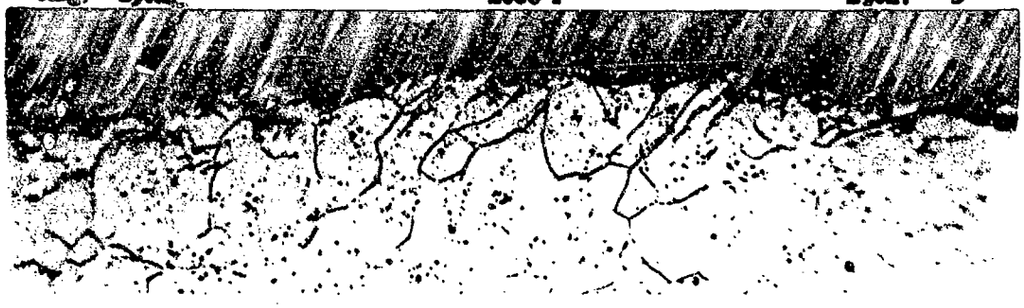


M 4607 Electrofilm 1005 on L-605 Figure 53
Mag: 250X 1000°F Etch: C

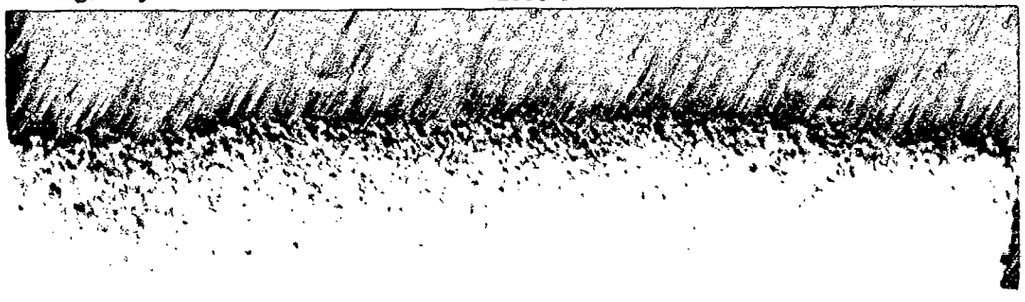
M 4608 Electrofilm 1005 on Hastelloy X Figure 54
Mag: 250X 1000°F Etch: C



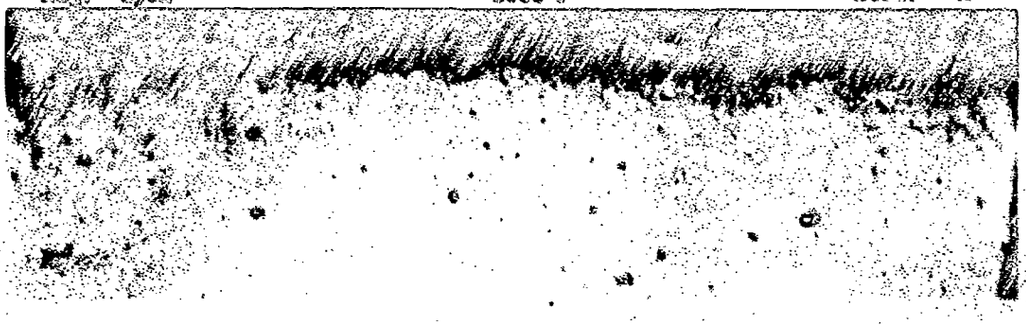
M 4609 Electrofilm 1005 on 310 SS Figure 55
Mag: 250X 1000°F Etch: D



M 4610 Electrofilm 1005 on 4130 Steel Figure 56
Mag: 250X 1000°F Etch: E

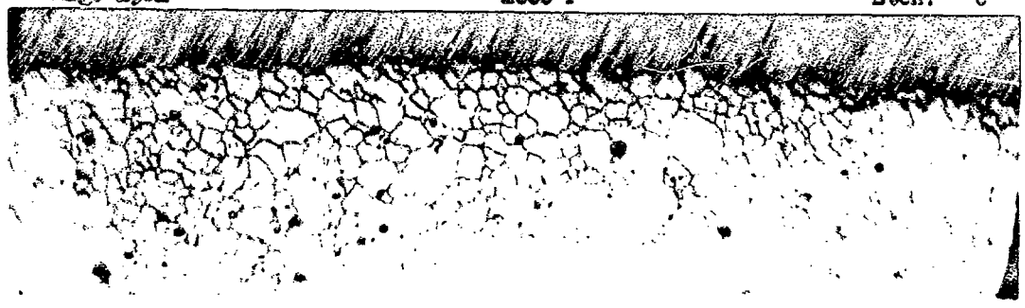


M 4611 Electrofilm 2007 on Inconel X Figure 57
Mag: 250X 1000°F Etch: A



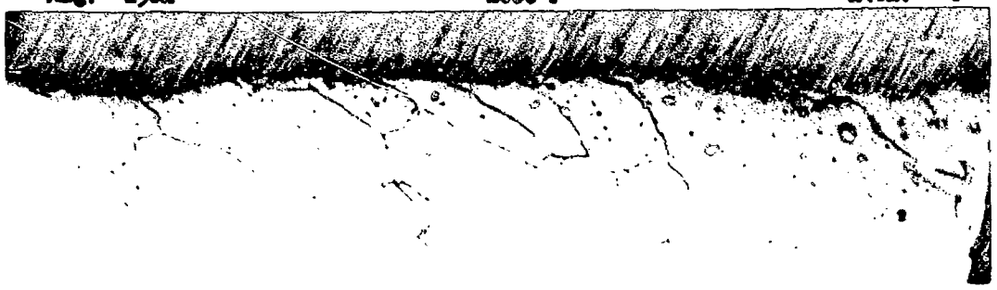
M 4612 Electrofilm 2007 on A-286 Figure 58
Mag: 250X 1000°F Etch: B

M 4613 Electrofilm 2007 on René 41 Figure 59
Mag: 250X 1000°F Etch: C

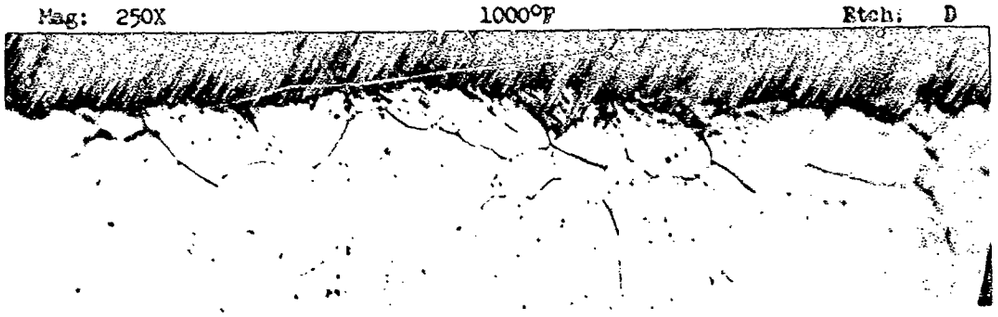


M 4614 Electrofilm 2007 on L-605 Figure 60
Mag: 250X 1000°F Etch: C

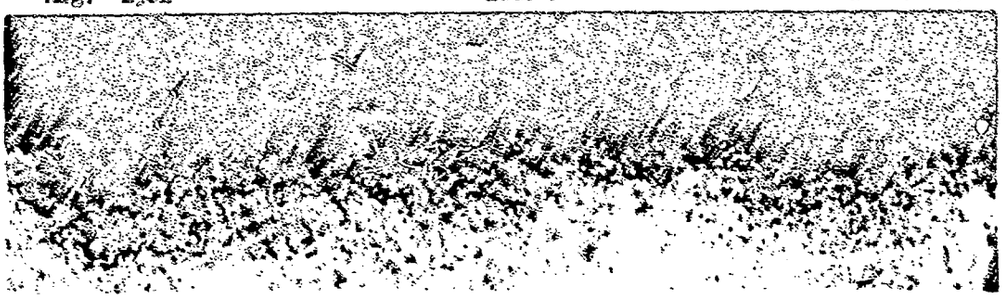
M 4615 Electrofilm 2007 on Hastalloy X Figure 61
Mag: 250X 1000°F Etch: C



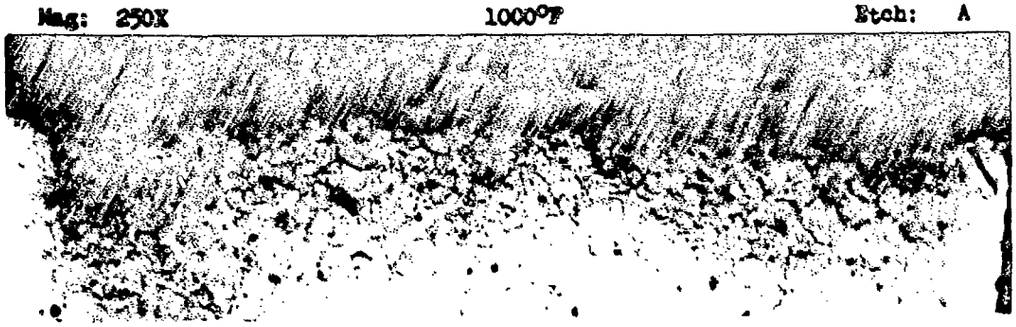
M 4616 Electrofilm 2007 on 310 SS Figure 62
Mag: 250X 1000°F Etch: D



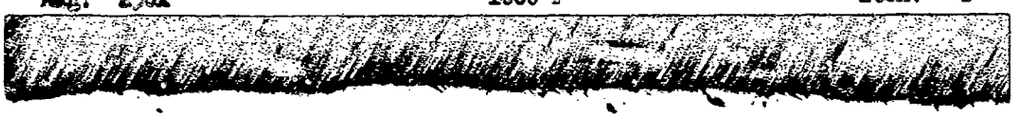
M 4617 Electrofilm 2007 on 4130 Steel Figure 63
Mag: 250X 1000°F Etch: E



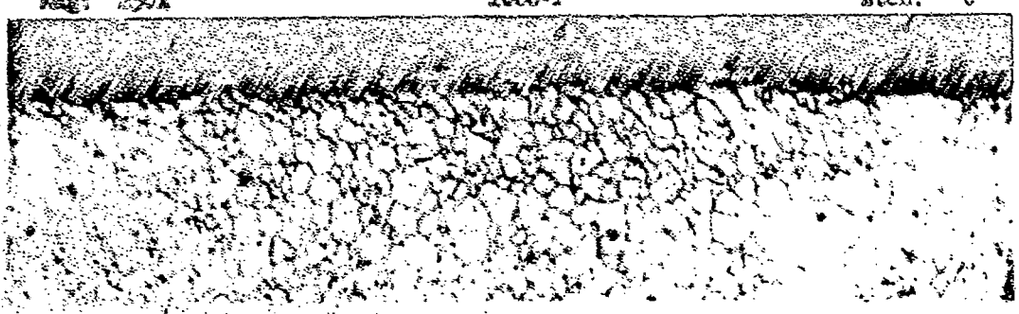
M 4618 Electrofilm 66C on Inconel X Figure 64
Mag: 250X 1000°F Etch: A



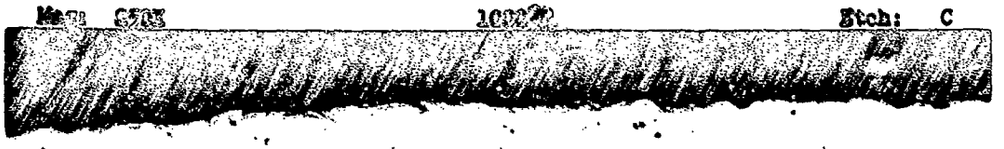
M 4619 Electrofilm 66C on A-286 Figure 65
Mag: 250X 1000°F Etch: B



M 4620 Electrofilm 66C on Hanŏ 41 Figure 66
Mag: 250X 1000°F Etch: C



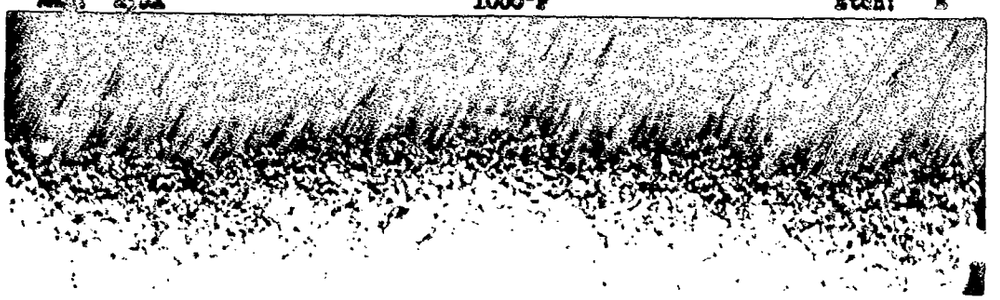
M 4621 Electrofilm 66C on L-605 Figure 67
Mag: 250X 1000°F Etch: C



M 4622 Electrofilm 66C on Hastelloy X Figure 68
Mag: 250X 1000°F Etch: C

M 4623 Electrofilm 66C on 310 SS Figure 69
Mag: 250X 1000°F Etch: D

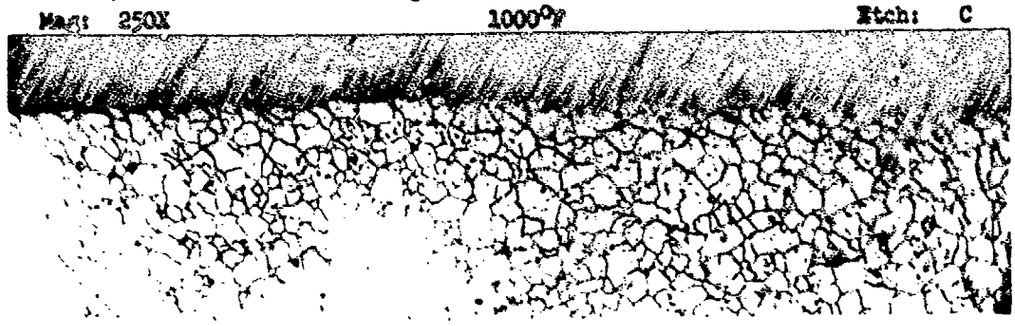
M 4624 Electrofilm 660 on 4130 Steel Figure 70
Mag: 250X 1000°F Etch: B



M 4625 Phosphatherm RM on Inconel X Figure 71
Mag: 250X 1000°F Etch: A

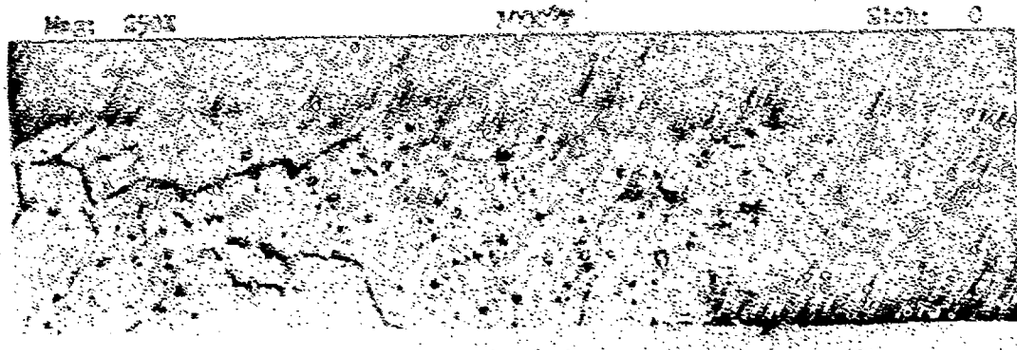
M 4626 Phosphatherm RM on A-286 Figure [illegible]
Mag: 250X 1000°F Etch: B

M 4627 Phosphatherm RM on Rene 41 Figure 73
Mag: 250X 1000°F Etch: C

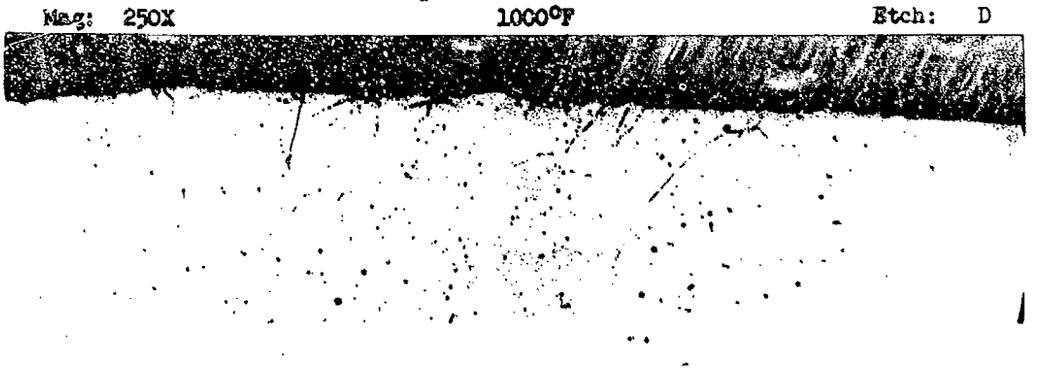


M 4628 Phosphatherm RM on L-605 Figure 74
Mag: 250X 1000°F Etch: C

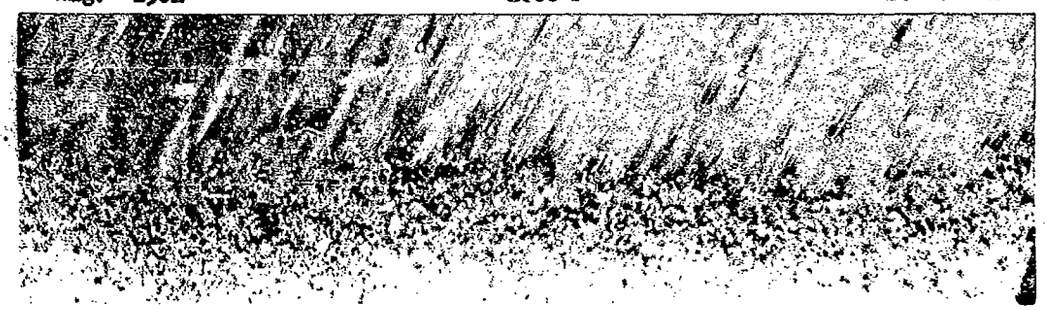
M 4629 Phosphatherm RM on Hastelloy X Figure 75
Mag: 250X 1000°F Etch: C



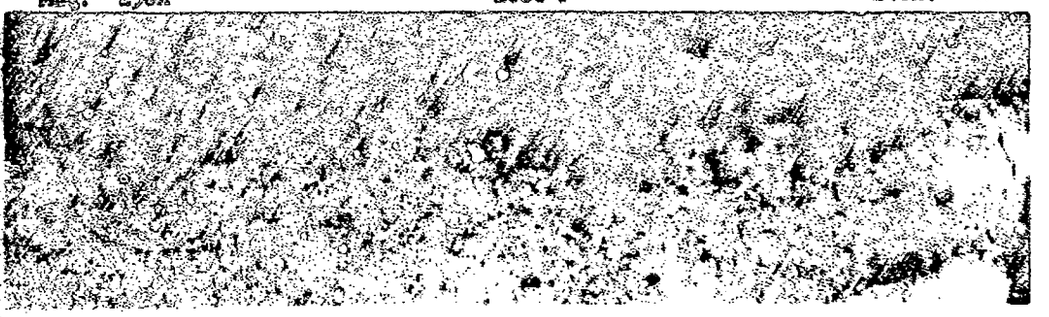
M 4630 Phosphatherm RH on 310 SS Figure 76
Mag: 250X 1000°F Etch: D



M 4631 Phosphatherm RH on 4130 Steel Figure 77
Mag: 250X 1000°F Etch: E

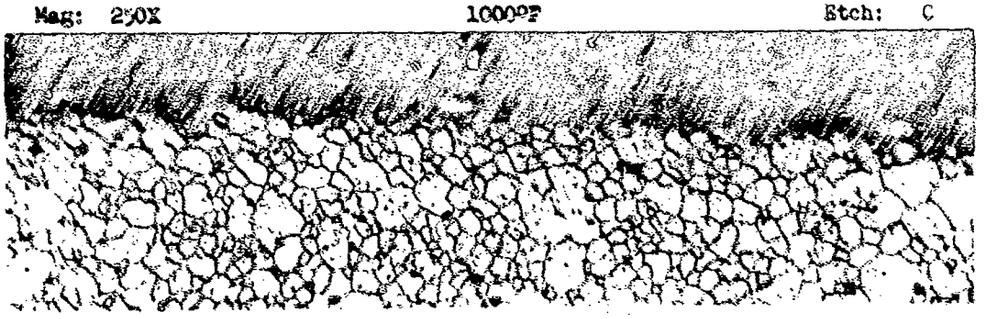


M 4632 Molykote X-106H on Inconel X Figure 78
Mag: 250X 1000°F Etch: A



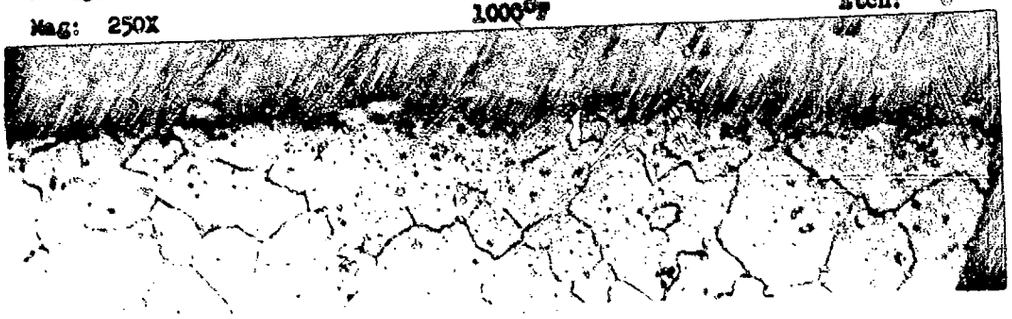
M 4633 Molykote X-106M on A-286 Figure 79
Mag: 250X 1000°F Etch. B

M 4634 Molykote X-106M on René 41 Figure 80
Mag: 250X 1000°F Etch: C

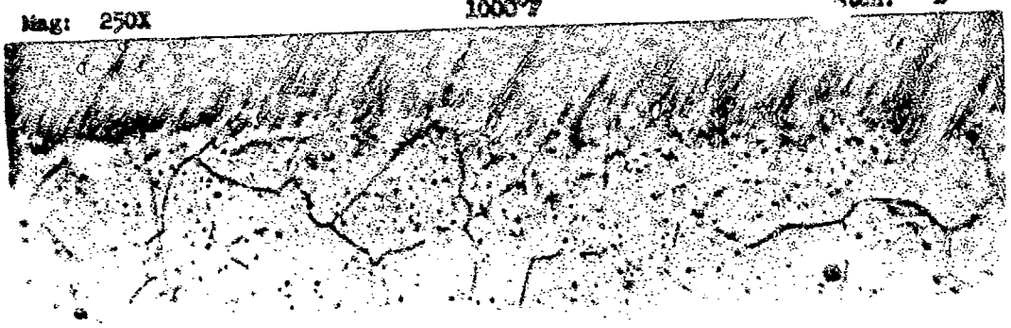


M 4635 Molykote X-106M on L-605 Figure 81
Mag: 250X 1000°F Etch: C

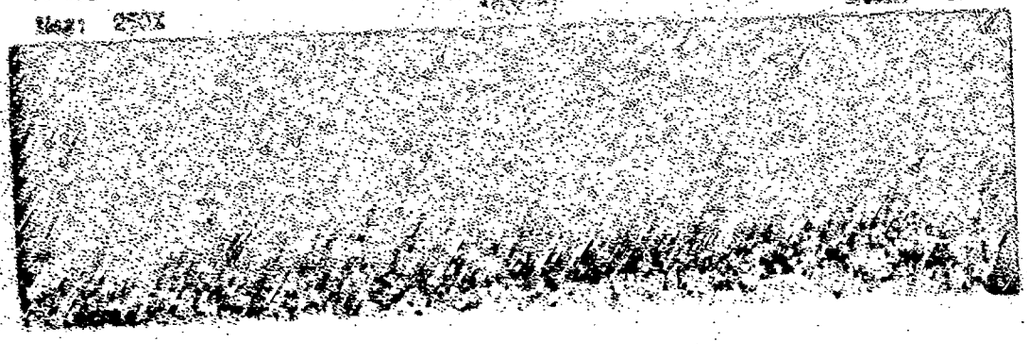
N 4636 Molykote Z-106M on Hastelloy X Figure 82
Mag: 250X 1000°F Etch: C



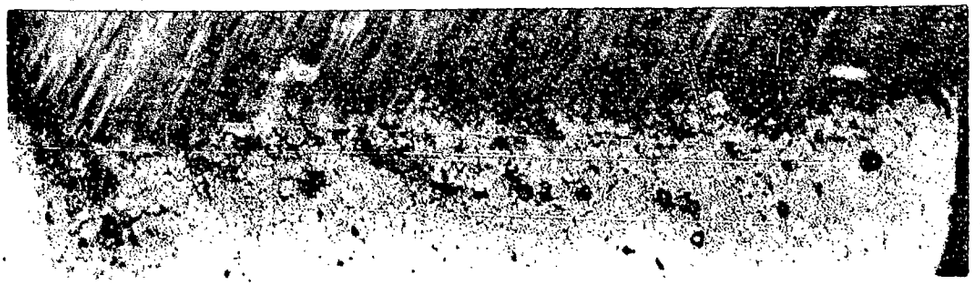
N 4637 Molykote Z-106M on 310 SS Figure 83
Mag: 250X 1000°F Etch: D



N 4638 Molykote Z-106M on A-286 Steel Figure 84
Mag: 250X Etch: E

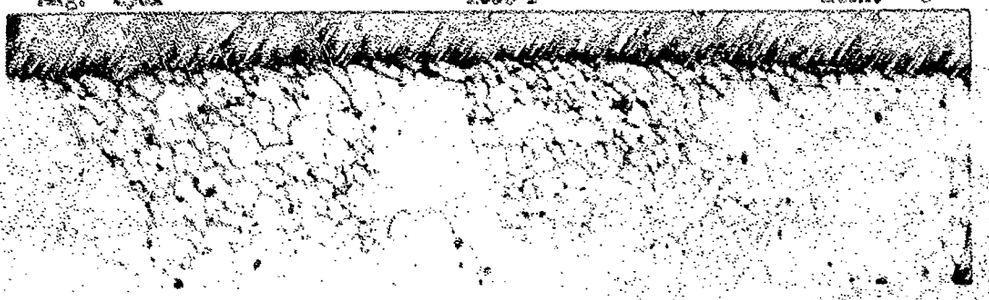


M 4639 Sodium Silicate on Inconel X Figure 85
Mag: 250X 1000°F Etch: A

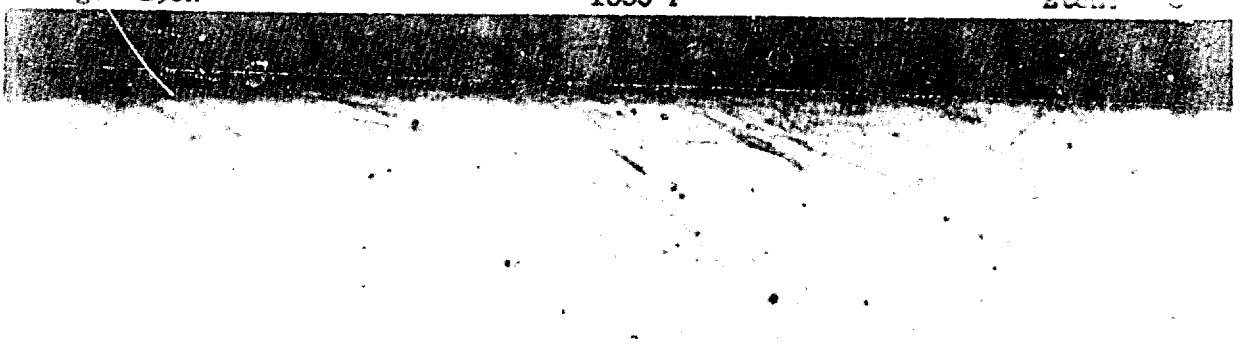


M 4640 Sodium Silicate on A-286 Figure 86
Mag: 250X 1000°F Etch: B

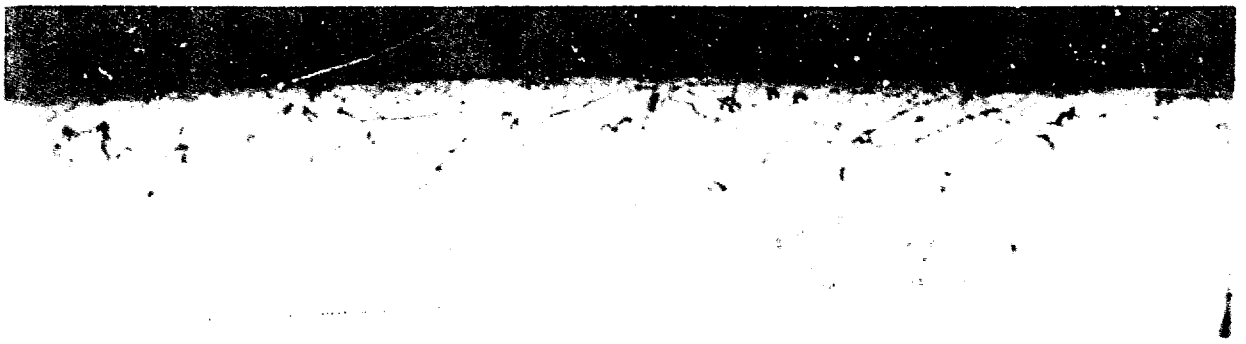
M 4641 Sodium Silicate on René 41 Figure 87
Mag: 250X 1000°F Etch: C



M-643 Sodium Silicate on L-605 Figure 58
Mag. 250X 1000°F Etch: C

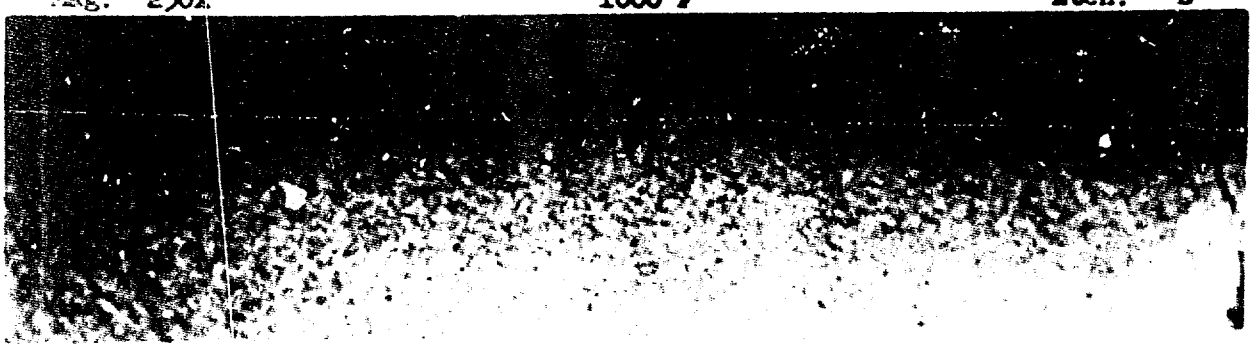


M 4643 Sodium Silicate on Hastelloy X Figure 59
Mag: 250X 1000°F Etch: C

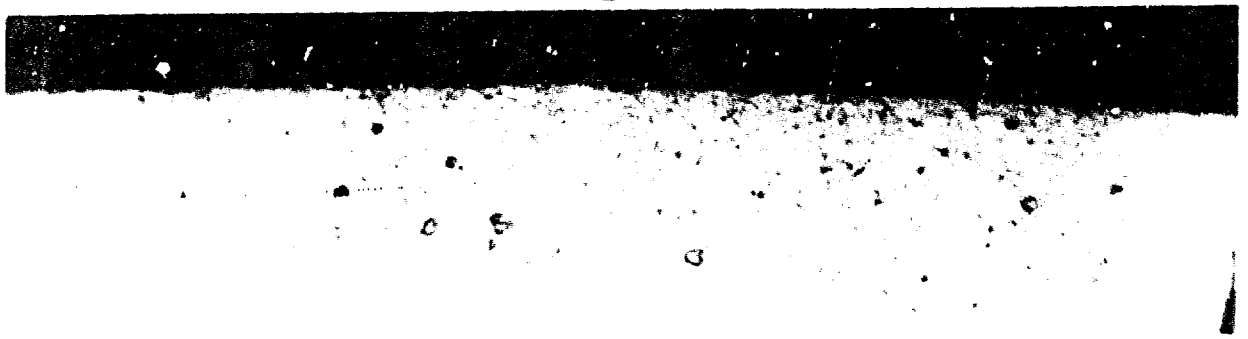


M 4644 Sodium Silicate on 310 SS Figure 60
Mag: 250 X 1000°F Etch: D

M 4645 Sodium Silicate on 4130 Steel Figure 91
Mag: 250X 1000°F Etch: E

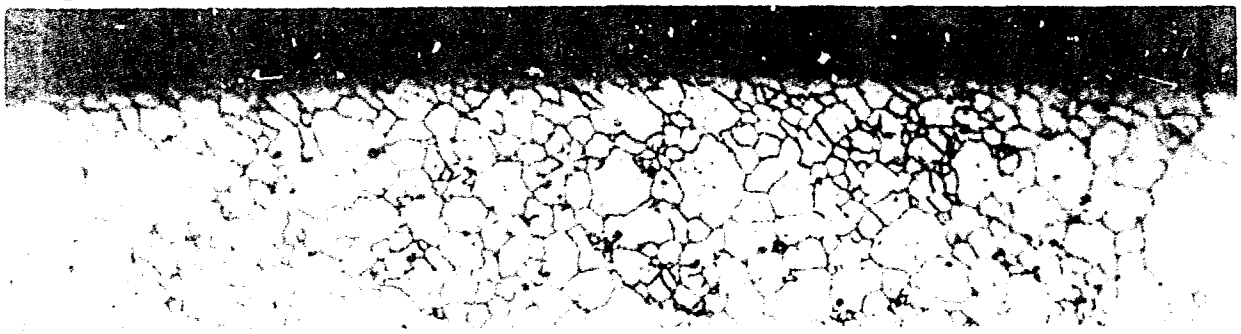


M 4646 Silica on Inconel X Figure
Mag: 250X 1000°F Etch: A

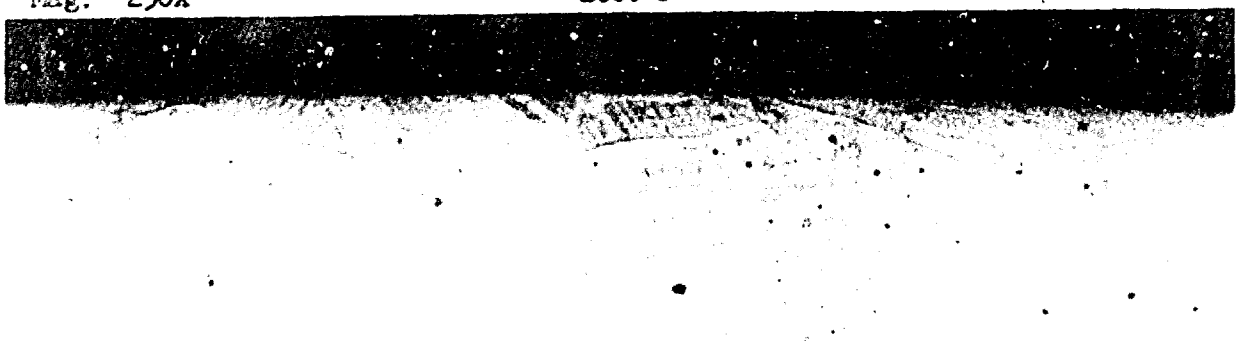


M 4647 Silica on A-286 Figure
Mag: 250X 1000°F Etch: B

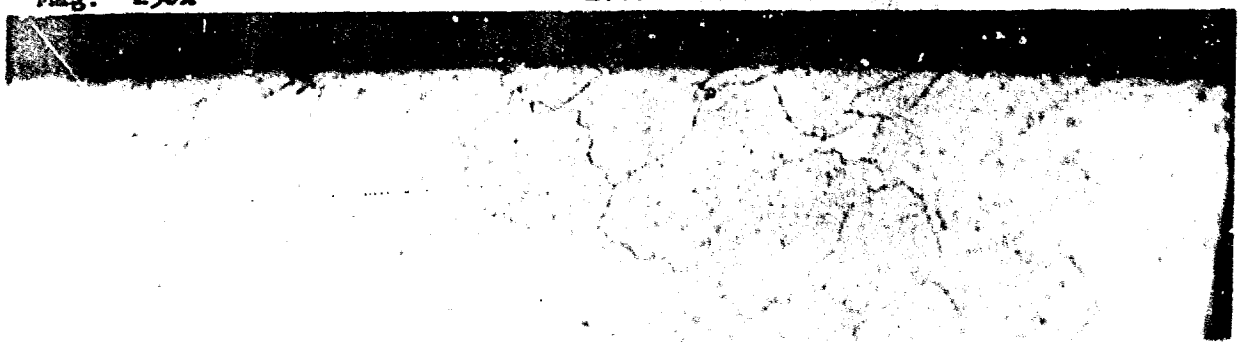
M 4647 Silica on Rene' 41 Figure
Mag: 250X 1000°F Etch: C



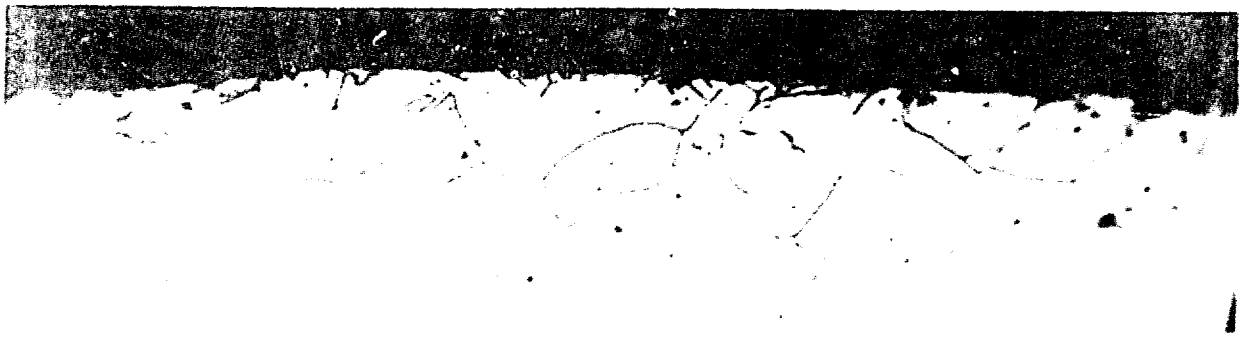
M 4649 **Silica on L-605** Figure 95
Mag: 250X **1000°F** Etch: C



M 4650 **Silica on Hastelloy X** Figure 96
Mag: 250X **1000°F** Etch: C



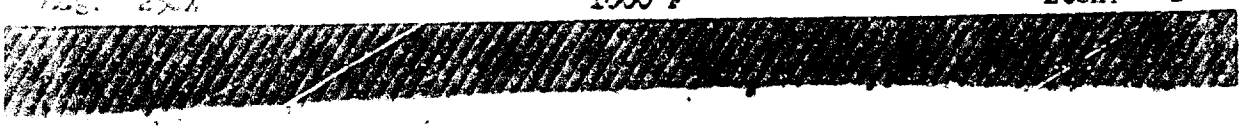
M 4651 Silica on 310 SS Figure 97
Mag: 250X 1000°F Etch: B



M 4652 Silica on 4130 Steel Figure 98
Mag: 250X 1000°F Etch: B

M 4653 Milk of Magnesia on Inconel X Figure 99
Mag: 250X 1000°F Etch: A

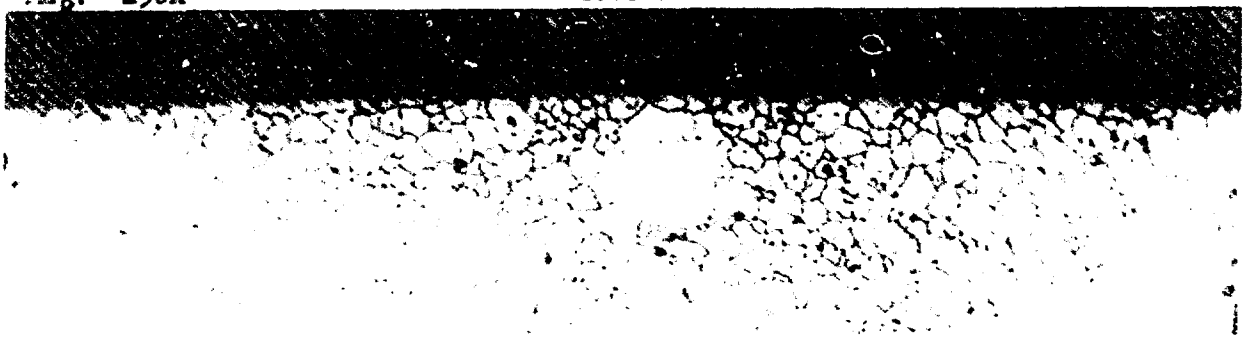
Milk of Magnesia on A-286
Mag: 250X
1000°F
Figure
Etch: B



M 4655
Mag: 250X

Milk of Magnesia on Rene'41
1000°F

Figure 101
Etch: C

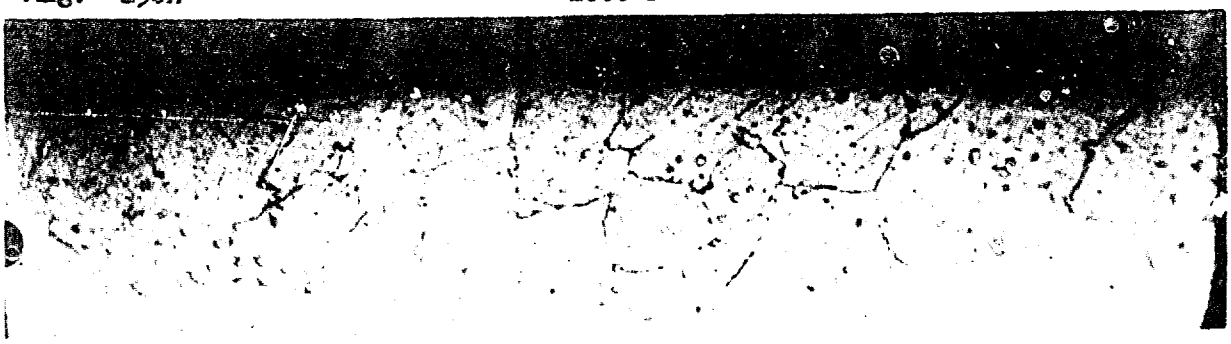


M 4656
Mag: 250X

Milk of Magnesia on L-605
1000°F

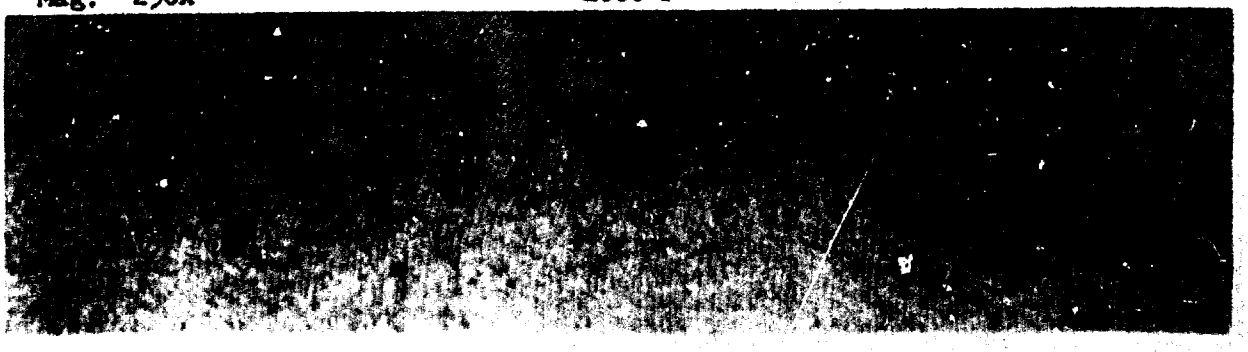
Figure
Etch:

M 4657 Milk of Magnesia on Hastelloy X Figure 103
Mag: 250X 1000°F Etch: C

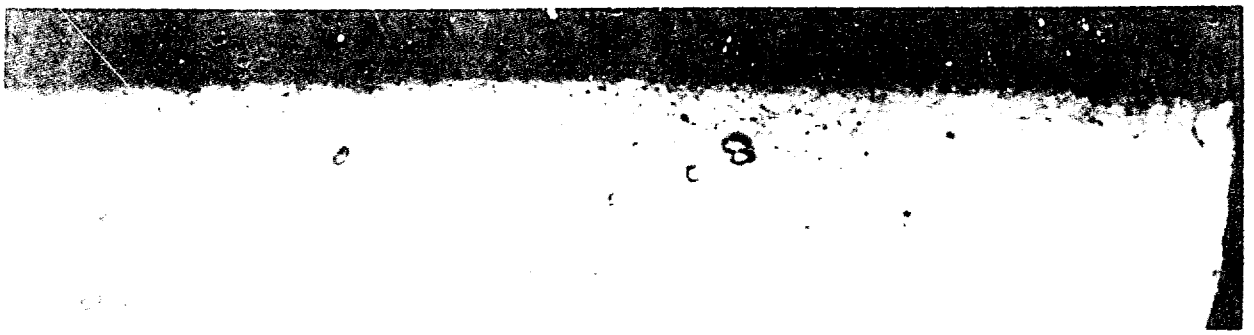


M 4658 Milk of Magnesia on 310 SS Figure 104
Mag: 250 X 1000°F Etch: D

M 4659 Milk of Magnesia on 4130 Steel Figure 105
Mag: 250X 1000°F Etch: E

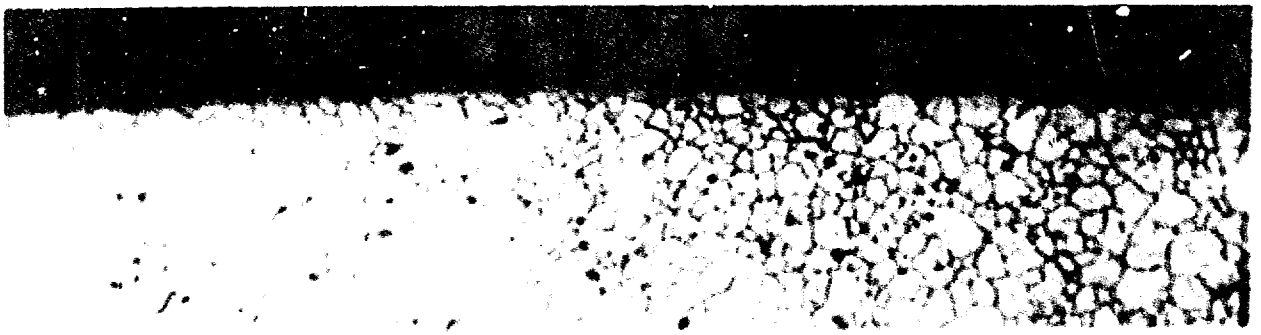


Magnesium Oxide on Inconel X
Mag: 250X — 1000°F — Etch: A

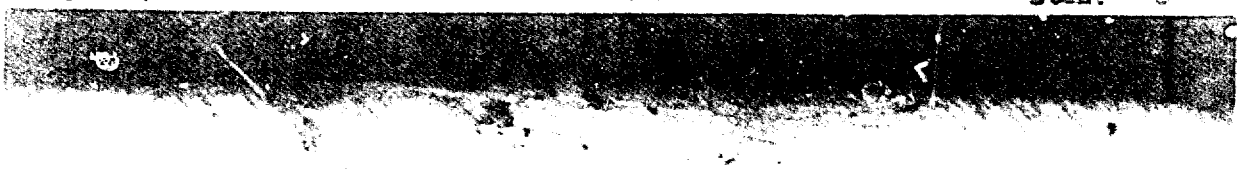


Magnesium Oxide on A-286
Mag: 250X — 1000°F — Etch: B

Magnesium Oxide on Rene'41
Mag: 250X — 1000°F — Etch: C



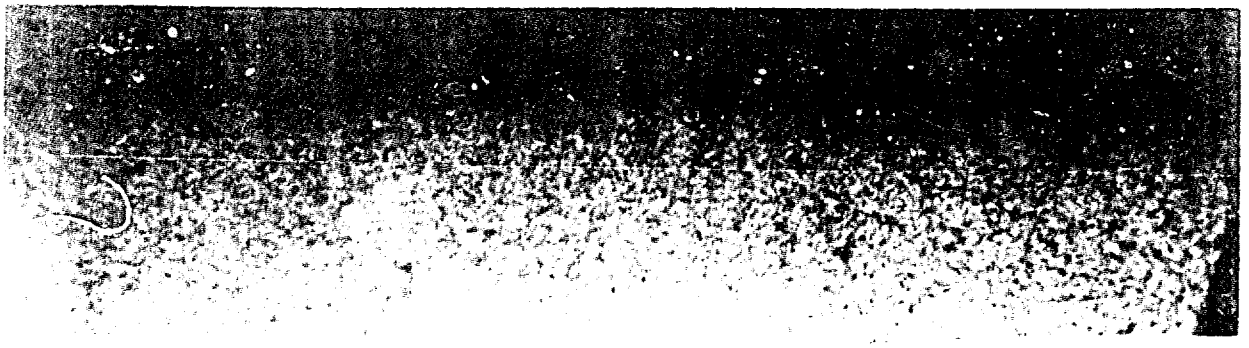
M 4663 Magnesium Oxide on L-605 Figure
Mag: 250X 1000°F Etch: C



M 4664 Magnesium Oxide on Hastelloy X Figure 110
Mag: 250X 1000°F Etch: C

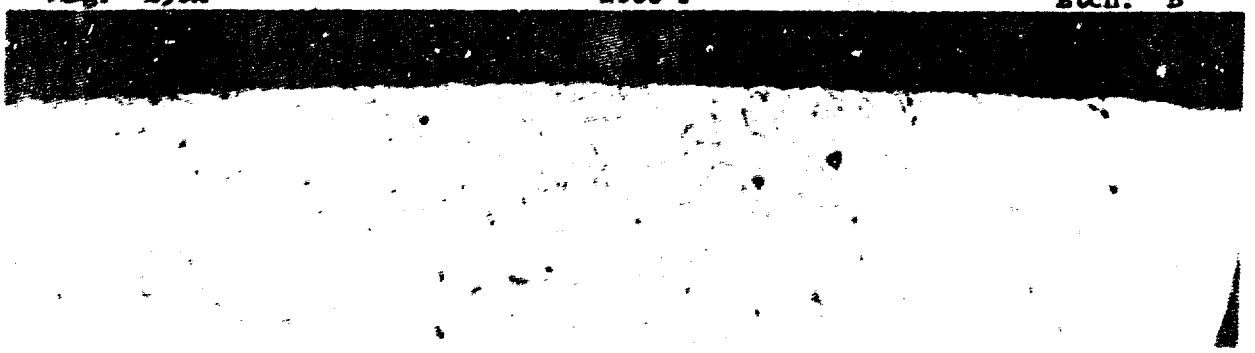
M 4665 Magnesium Oxide on 310 SS Figure 111
Mag: 250X 1000°F Etch: D

M 4666 Magnesium Oxide on 4130 Steel Figure 112
Mag: 250X 1000°F Etch: B



M 4667 Boron Nitride on Inconel X Figure 113
Mag: 250X 1000°F Etch: A

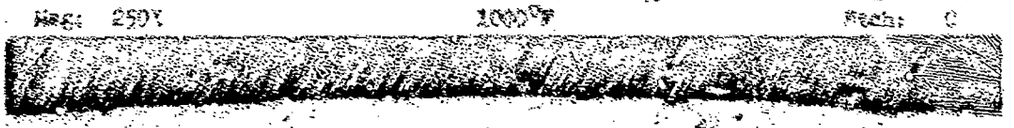
M 4668 Boron Nitride on A-286 Figure 114
Mag: 250X 1000°F Etch: B



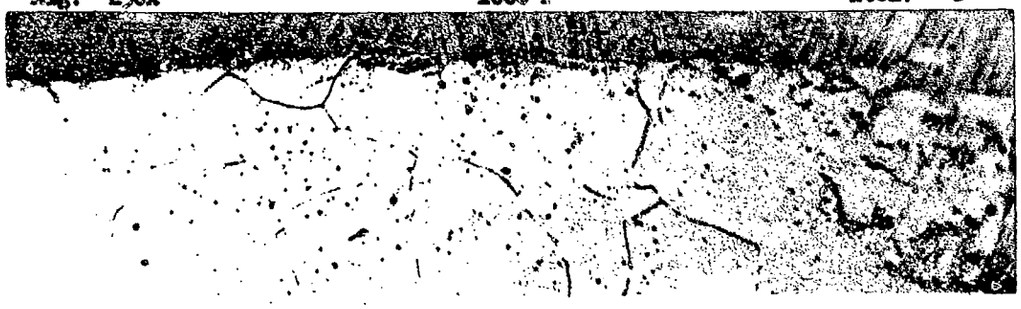
M 4669 Boron Nitride on Rene'41 Figure 115
Mag: 250X 1000°F Etch: C

M 4670 Boron Nitride on L-605 Figure 116
Mag: 250X 1000°F Etch: C

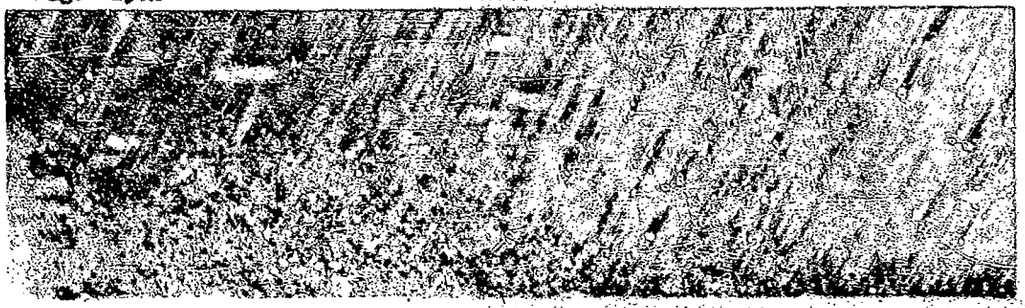
M 4671 Boron Nitride on Hastelloy X Figure 117
Mag: 250X 1000°F Etch: C



M 4672 Boron Nitride on 310 SS Figure 118
Mag: 250X 1000°F Etch: D

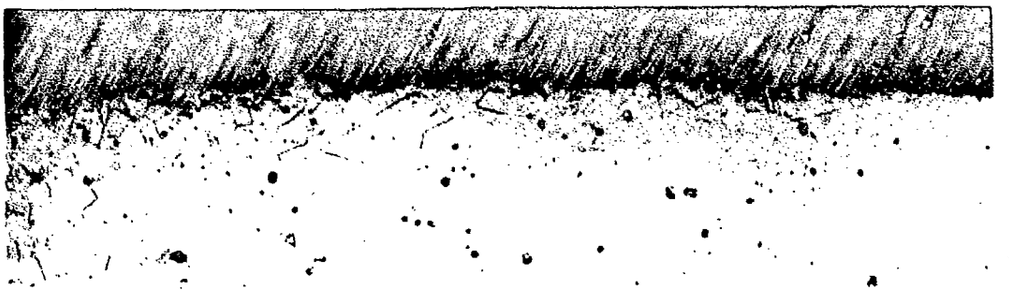


M 4673 Boron Nitride on 4130 Steel Figure 119
Mag: 250X 1000°F Etch: E

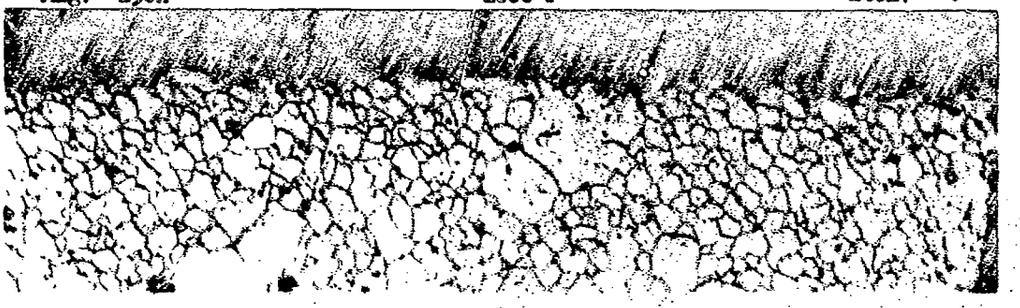


M 4674 Boron Carbide on Inconel X Figure 120
Mag: 250X Etch: A

M 4675 Boric Oxide on A-286 Figure 121
Mag: 250X 1000°F Etch: B



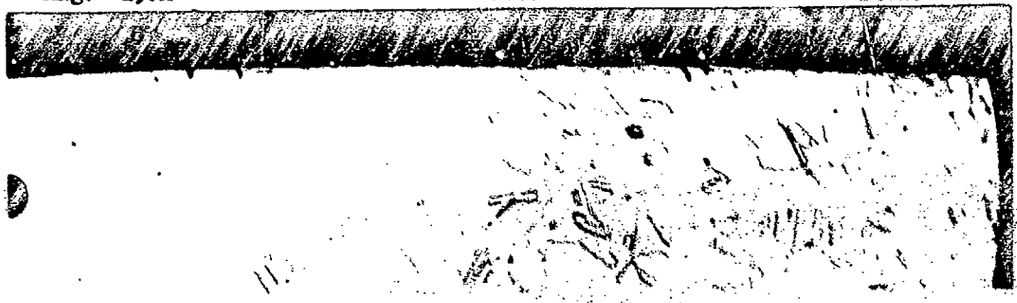
M 4676 Boric Oxide on Rene '41 Figure 122
Mag: 250X 1000°F Etch: C



M 4677 Boric Oxide on L-605 Figure 123
Mag: 250X 1000°F Etch: C

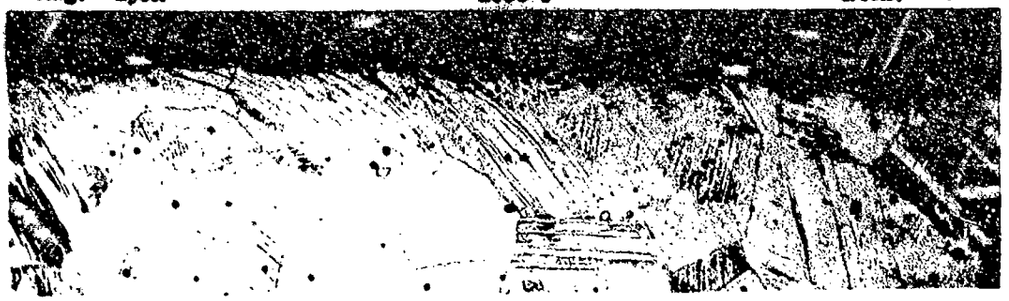
M 4681 MOLYKOTE X-106 ON INCONEL X Figure 127
Mag: 250X 1000°F Etch: A

M 4682 MOLYKOTE X-106 ON A-286 Figure 128
Mag: 250X 1000°F Etch: B



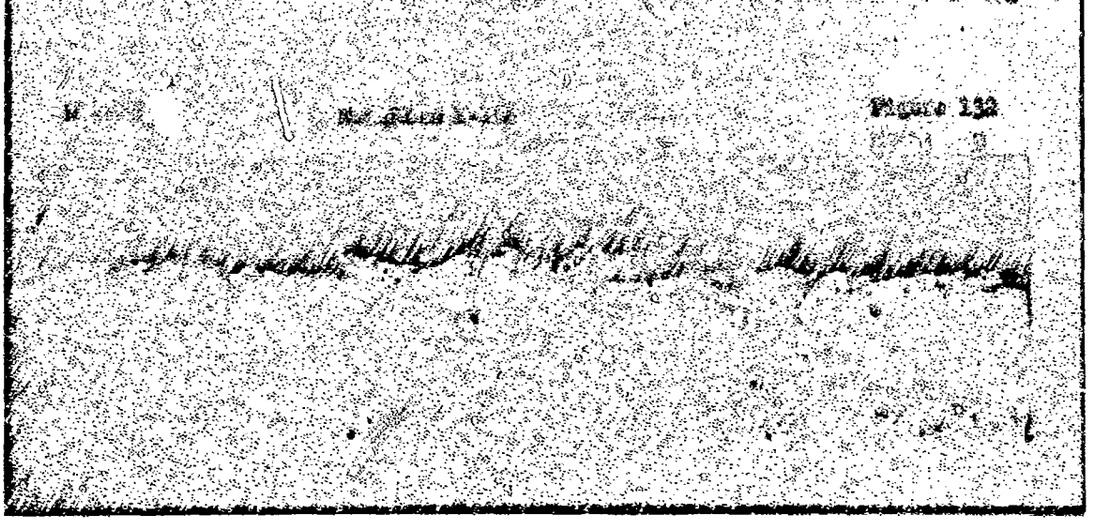
M 4683 MOLYKOTE X-106 ON [illegible] Figure 129
Mag: 250X Etch: [illegible]

M 4684 MOLYKOTE X-106 ON L-605 Figure 130
Mag: 250X 1000°F Etch: C



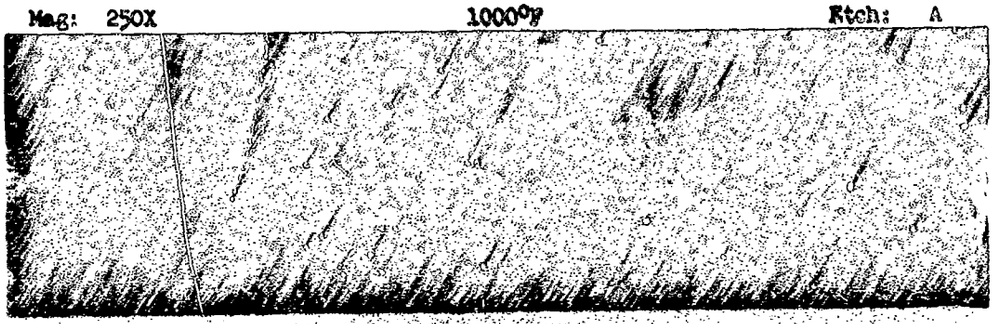
M 4685 MOLYKOTE X-106 ON HASTELLOY X Figure 131
Mag: 250 X 1000°F Etch: C

M [illegible] Figure 132

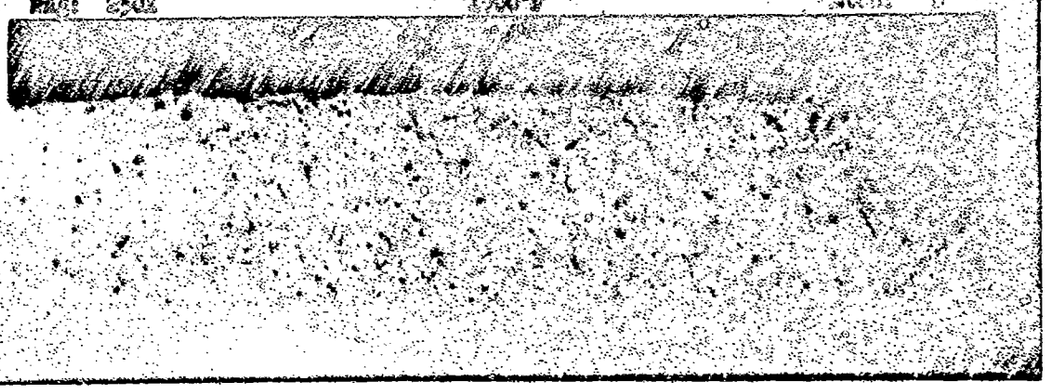


M 4687 Molykote X-10t On 4130 Figure 133
Mag: 250X 1000°F Etch: E

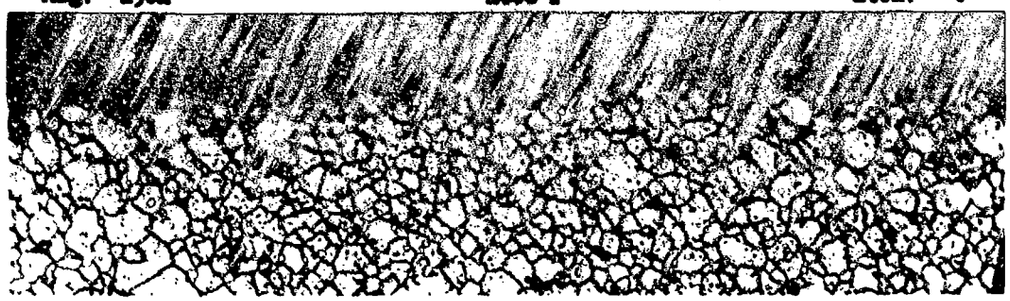
M 4688 Lead Monoxide on Inconel X Figure 134
Mag: 250X 1000°F Etch: A



M 4689 Lead Monoxide on A-286 Figure 135
Mag: 250X 1000°F Etch: B

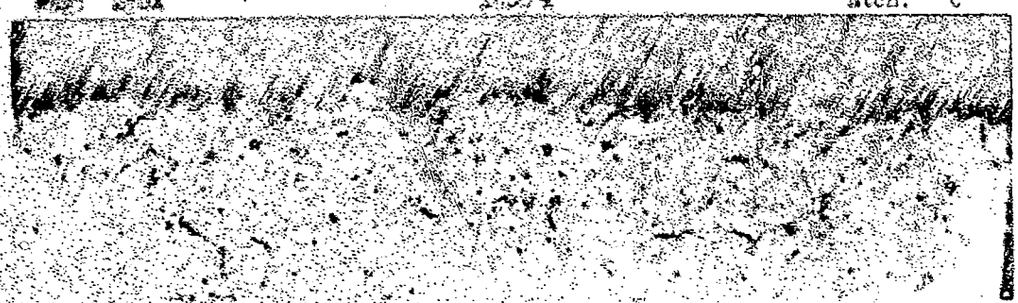


M 4690 Lead Monoxide on Rene '41 Figure 136
Mag: 250X 1000°F Etch: C

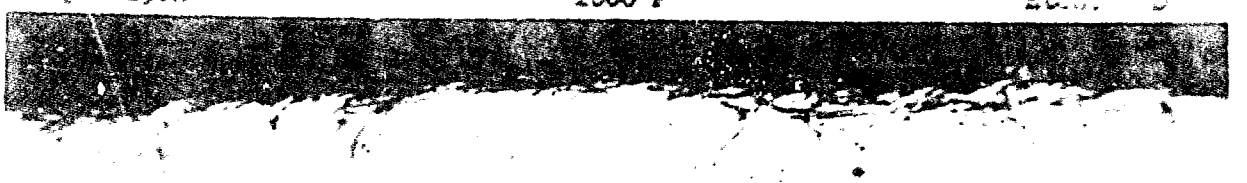


M 4691 Lead Monoxide on L-605 Figure 137
Mag: 250X 1000°F Etch: C

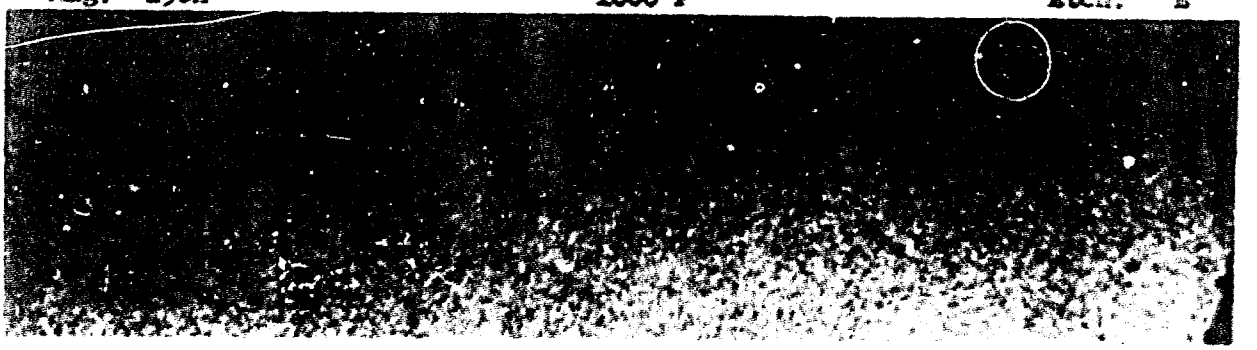
M 4692 Lead Monoxide on Hastelloy X Figure 1[illegible]
Mag: 250X 1000°F Etch: C



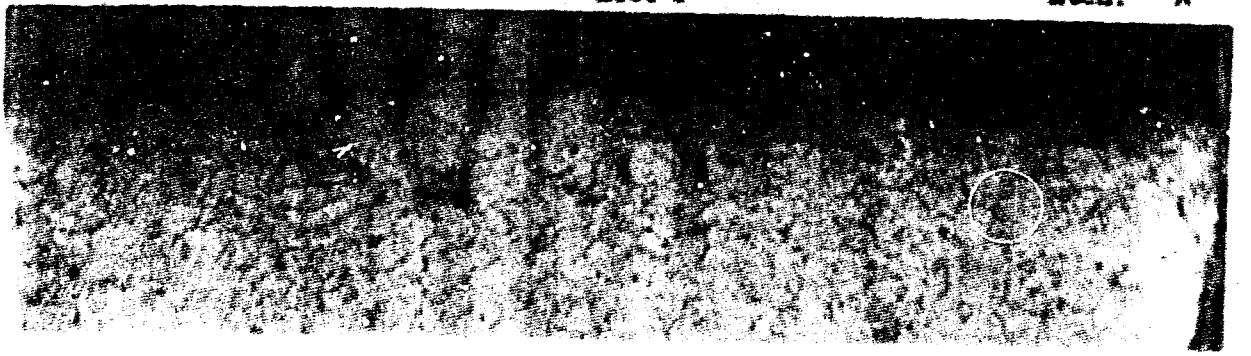
M 4693 Lead Monoxide on A10 SS Figure 139
Mag: 250X 1000°F Etch: B



M 4694 Lead Monoxide on 4130 Steel Figure 140
Mag: 250X 1000°F Etch: E

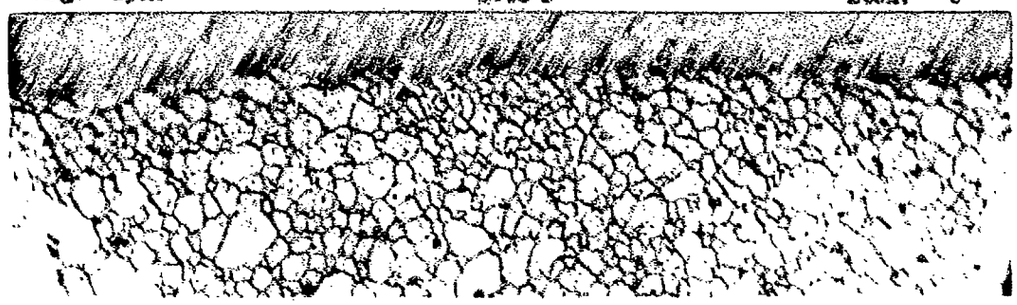


M 4695 Calcium Fluoride on Inconel X Figure 141
Mag: 250X 1000°F Etch: A

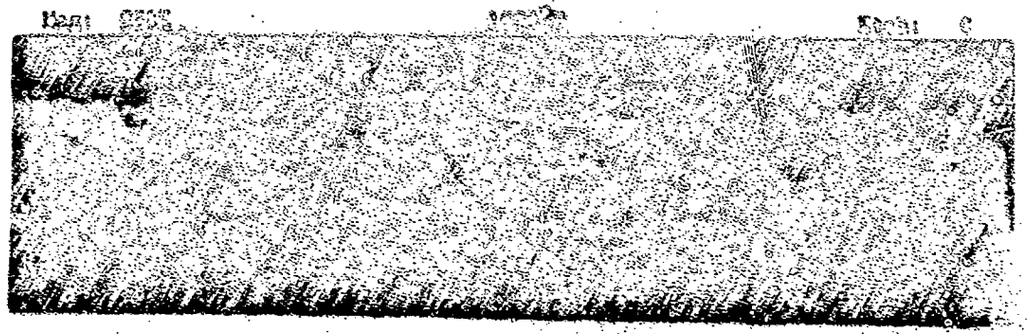


M 4696 Calcium Fluoride on A-286 Figure 142
Mag: 250X 1000°F Etch: B

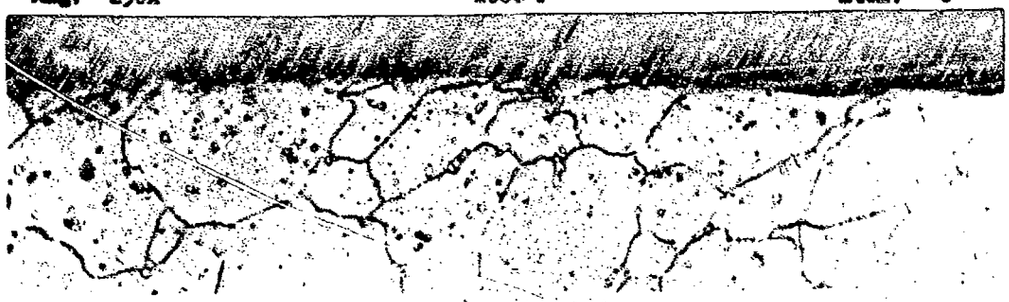
M 4697 Calcium Fluoride on René' 41 Figure 143
Mag: 250X 1000°F Etch: C



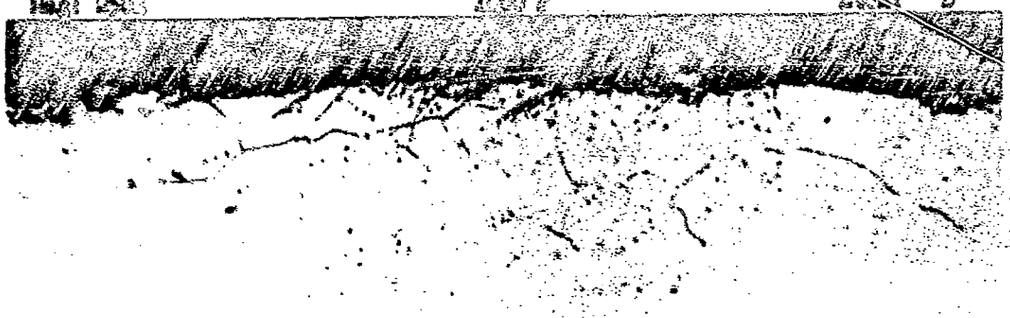
M 4698 Calcium Fluoride on L-605 Figure 144
Mag: 250X 1000°F Etch: C



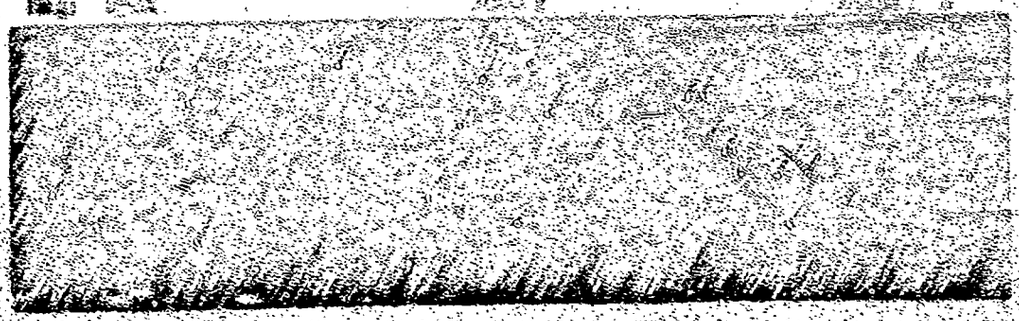
M 4699 Calcium Fluoride on Hastelloy X Figure 145
Mag: 250X 1000°F Etch: C



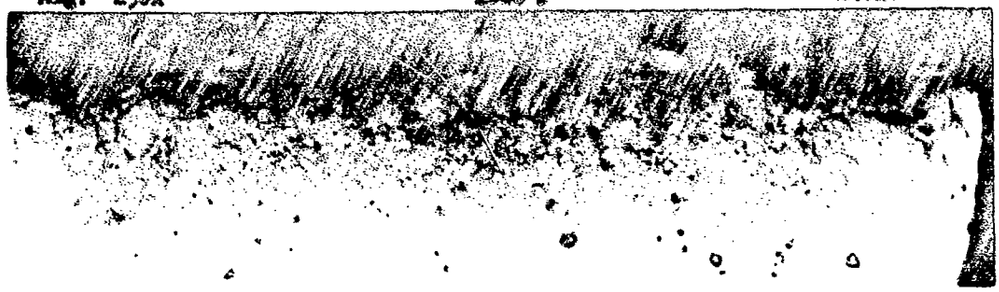
M 4700 Calcium Fluoride on 310 SS Figure 146
Mag: 250X 1000°F Etch: D



M 4701 Calcium Fluoride on 410 Steel Figure 147
Mag: 250X 1000°F Etch: B



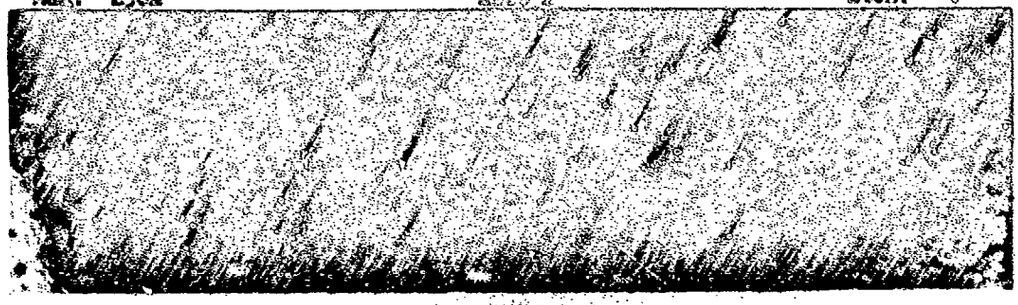
M 4702 Lead Sulfide on Inconel X Figure 148
Mag: 250X 1000°F Etch: A



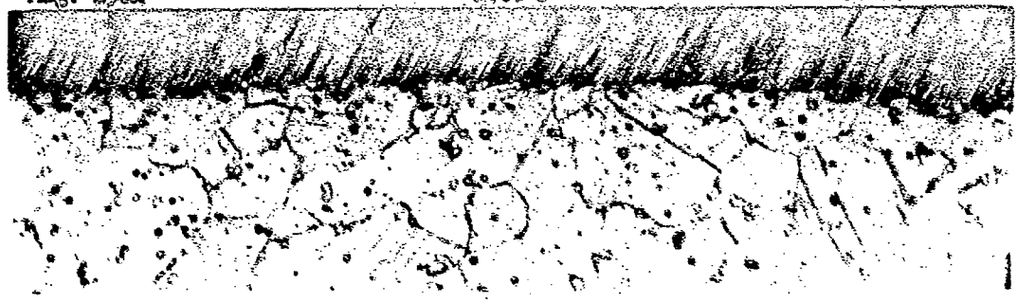
M 4703 Lead Sulfide on A-286 Figure 149
Mag: 250X 1000°F Etch: B

M 4704 Lead Sulfide on René 41 Figure 150
Mag: 250X Etch: C

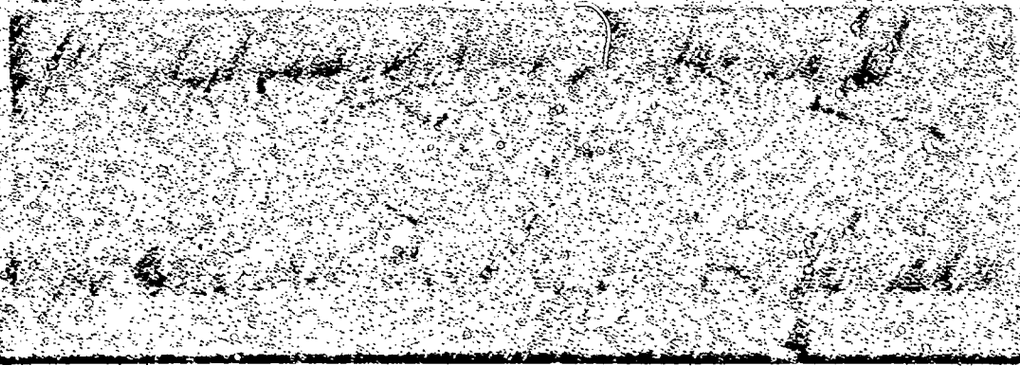
M 4705 Lead Sulfide on L-605 Figure 151
Mag: 250X 1000X Etch: C



M 4706 Lead Sulfide on Hastelloy X Figure 152
Mag: 250X 1000X Etch: C



M 4707 Lead Sulfide on 310 SS Figure 153
Mag: 250X 1000X Etch: D

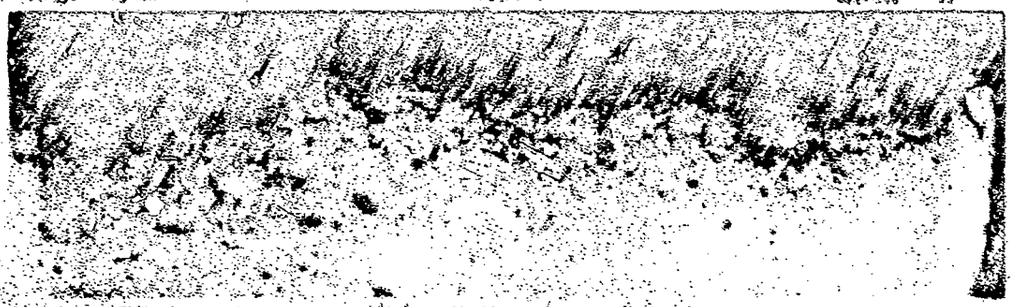


M 4708 Lead Sulfide on 4130 Steel Figure 154

Mag: 250X 1000°F Etch: E

M 4709 Inconel X in Air Figure 155

Mag: 250X 1000°F Etch: A



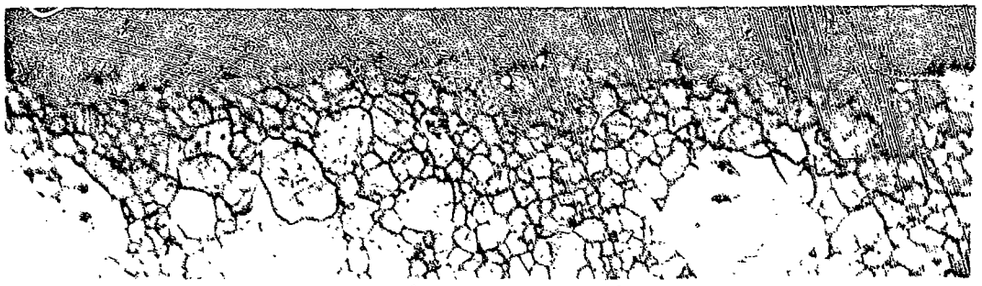
(Control Specimen)

M 4710 4-20G in Air Figure 156

Etch: A

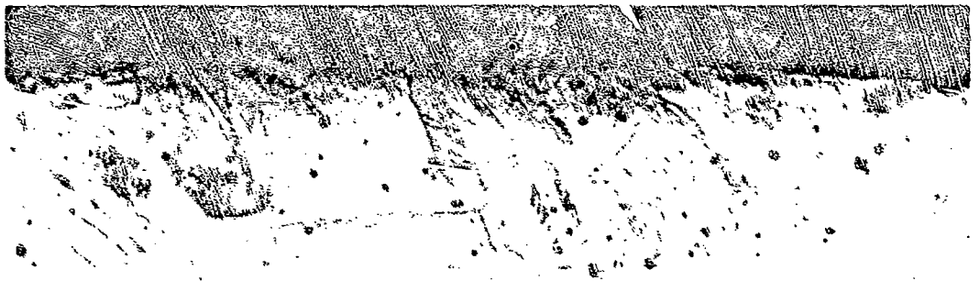
(Control Specimen)

M 4711 | Rene' 41 in Air | Figure 157
Mag: 250X | 1000°F | Etch: C



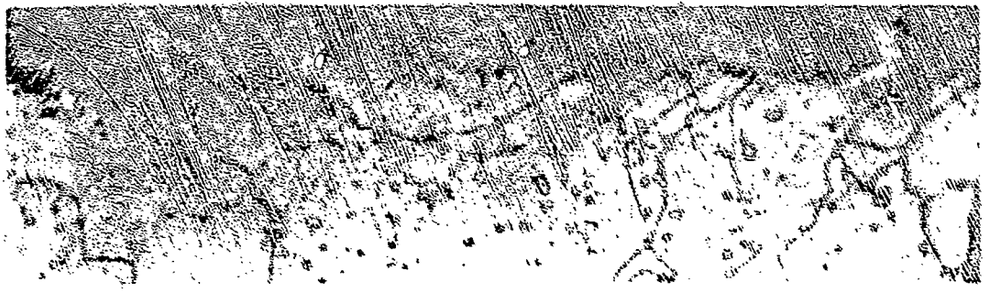
(Control Specimen)

M 4712 | L-605 in Air | Figure 158
Mag: 250X | 1000°F | Etch: C



(Control Specimen)

M 4713 | Hastelloy X in Air | Figure 159
Mag: 250X | 1000°F | Etch: C

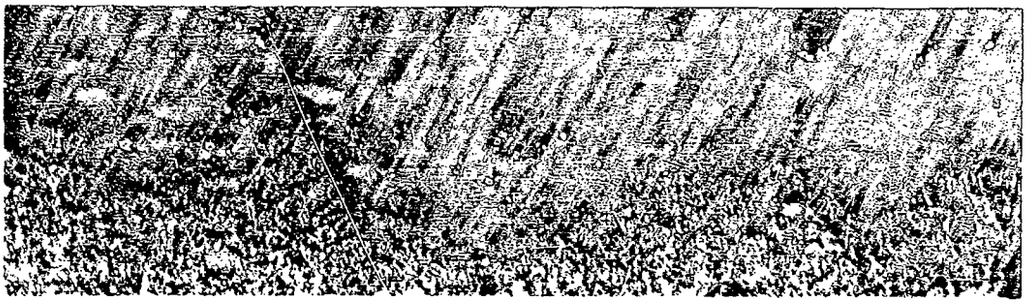


(Control Specimen)

M 4714 | 310 SS in Air | Figure 160
Mag: 250X | 1000°F | Etch: D

(Control Specimen)

M 4715 | 4130 Steel in Air | Figure 161
Mag: 250X | 1000°F | Etch: E



(Control Specimen)

INDEX OF PHOTOMICROGRAPHS OF 1000F EXPOSURE SPECIMENS

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ST. LOUIS, M

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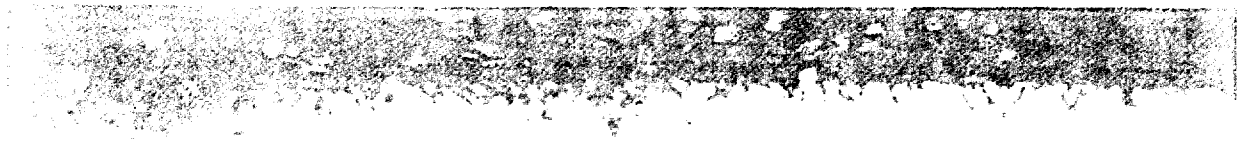
[illegible] Silver Coop on Inconel X — Figure 162
[illegible] 1200°F — Etch: A

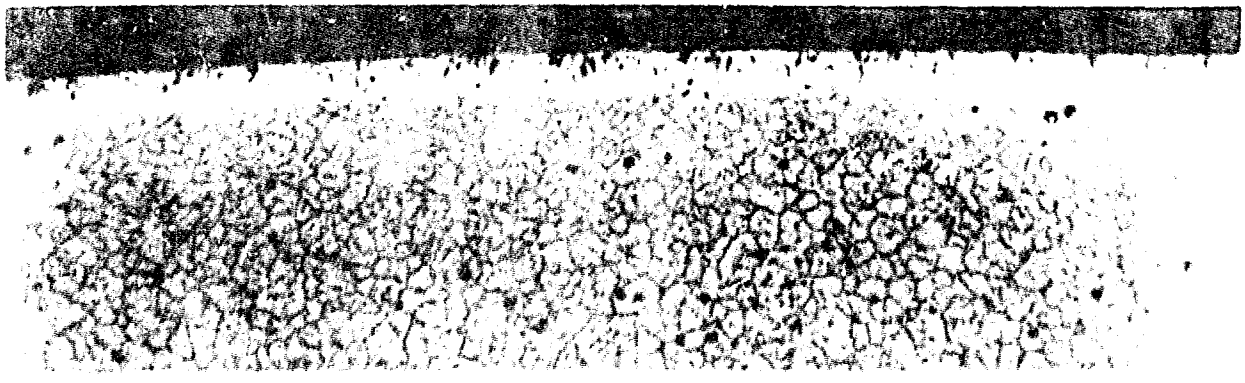


Film and Intergranular Oxidation

[illegible] 4304 — Silver Coop on A-286 — Figure 163
Mag: 250X — 1800°F — Etch: B

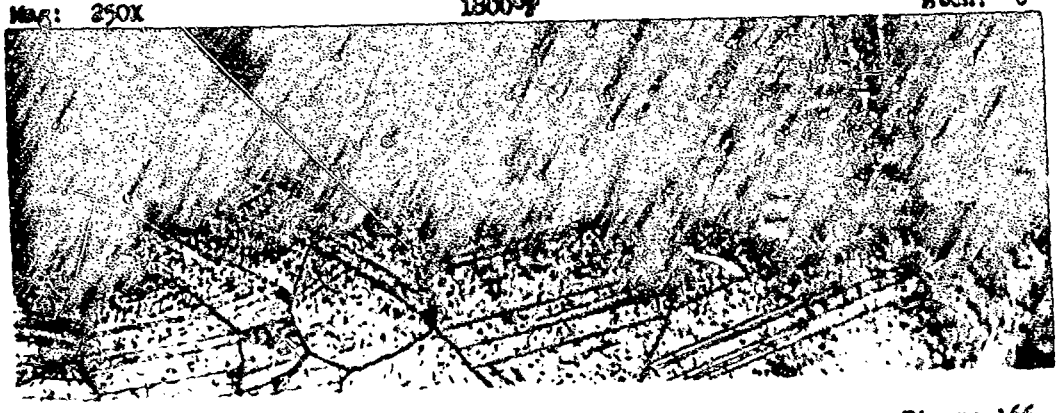
Film and Intergranular Oxidation

[illegible] 4305 — Silver Coop on Reng'41 — Figure 164
Mag: 250X — 1800°F — Etch: C

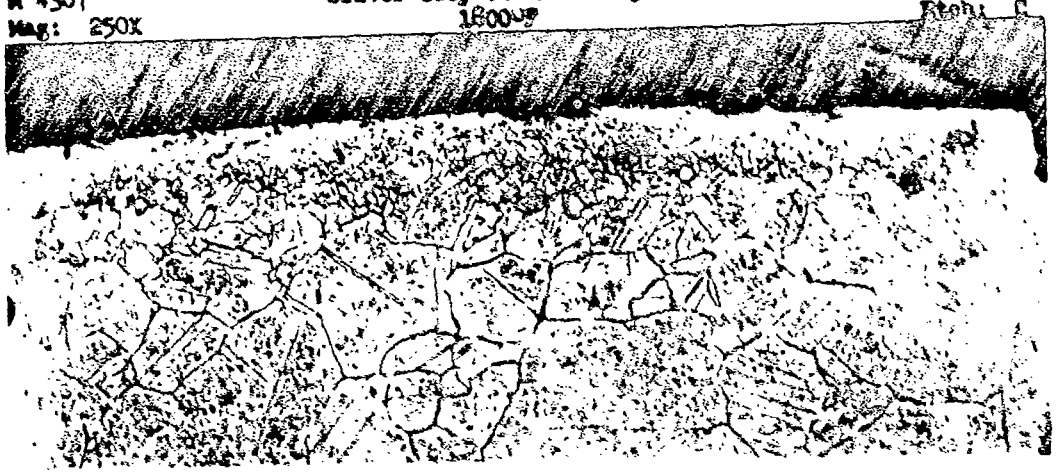


Oxidation and Slight Pitting

M 4306 Silver Goop on L-605 Figure 165
Mag: 250X 1800°F Etch: C



M 4307 Silver Goop on Hastelloy X Figure 166
Mag: 250X 1800°F Etch: C

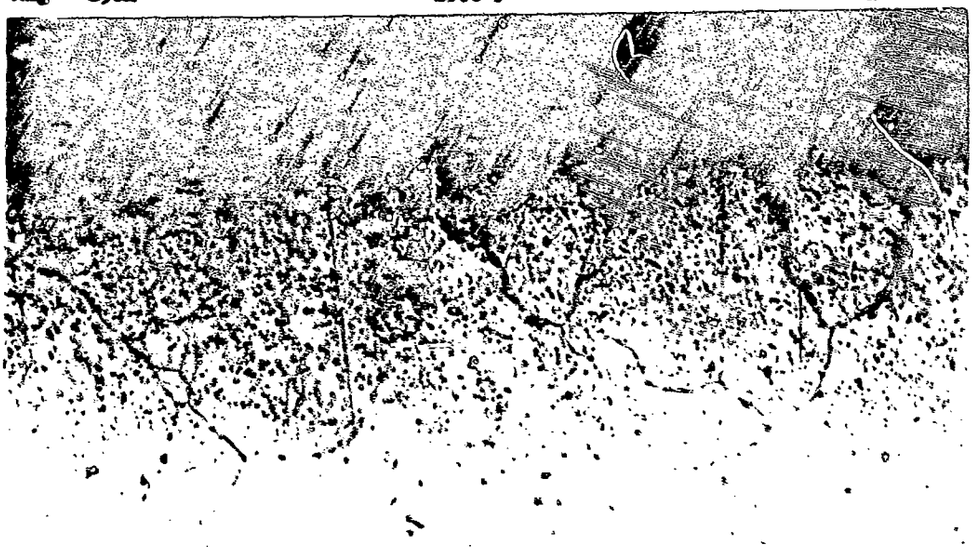


M 4308 Silver Goop on 310 S.S. Figure 167
Mag: 250X 1800°F Etch: D

M 4309 Base Off 990 on Inconel X Figure 168
Mag: 250X 1800°F Etch: A

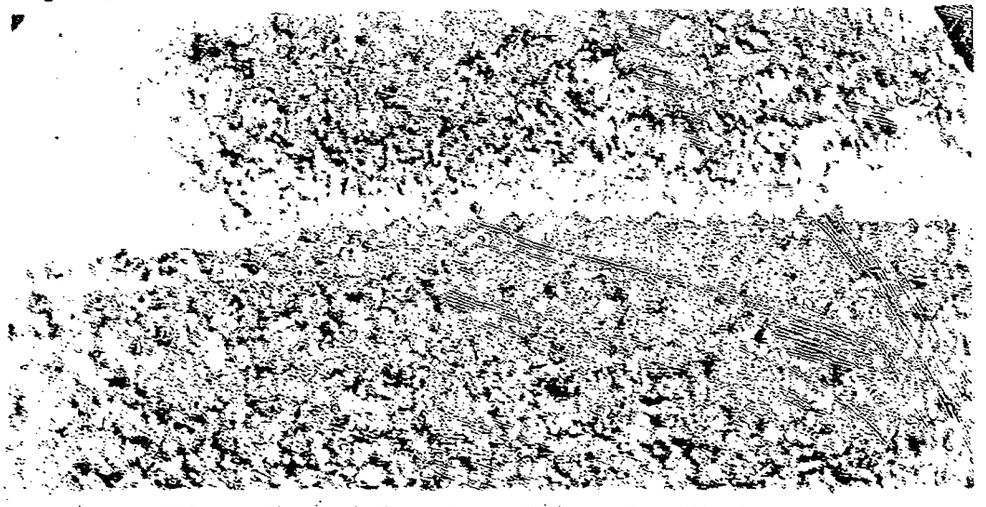
Extreme Oxidation, Pitting, and Corrosive Alloying

M 4310 Etch 0ff 990 on A-286 Figure 169
Mag: 250X 1800°F Etch: B



Intergranular Attack and Chemical Corrosion

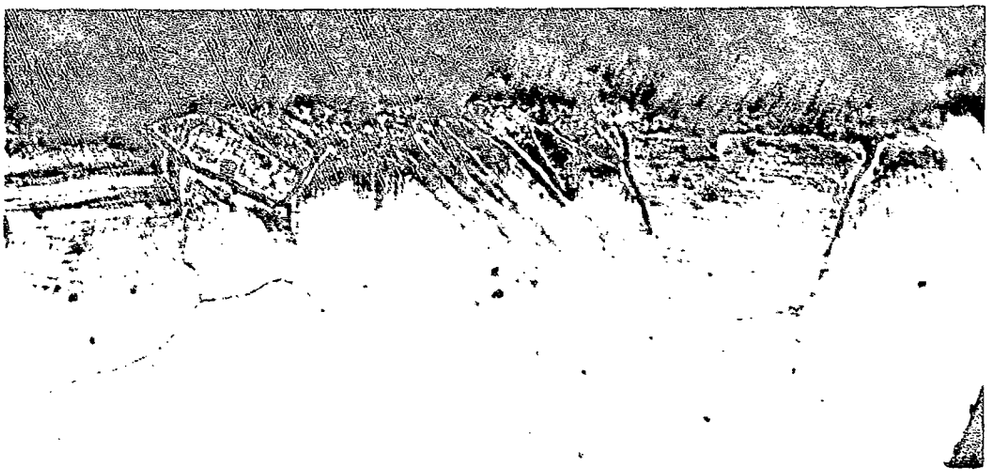
M 4311 Etch 0ff 990 on Rene' 41 Figure 170
Mag: 250X 1800°F Etch: C



Extreme Chemical Corrosion & Corrosive Alloying

N 4312 Base Off 990 on L-605 Figure 171

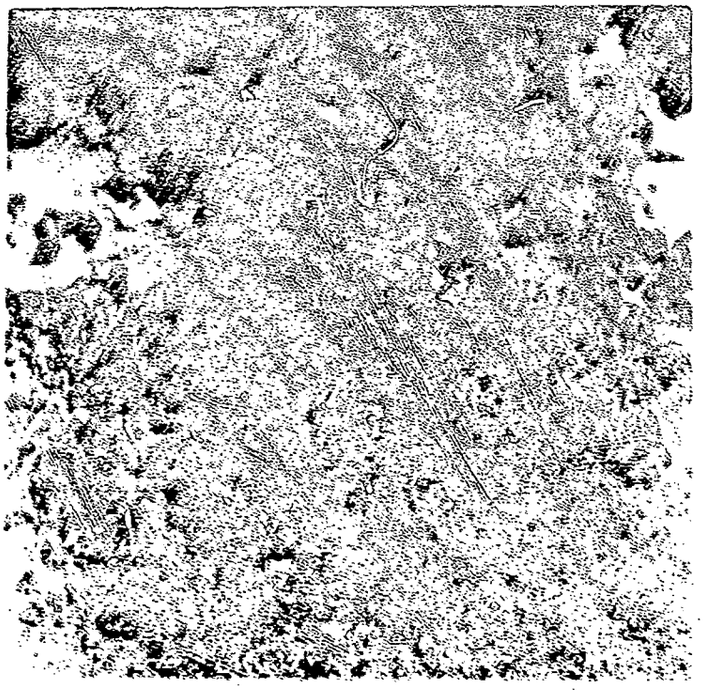
Mag: 250X 1800°F Etch: C



Intergranular Attack

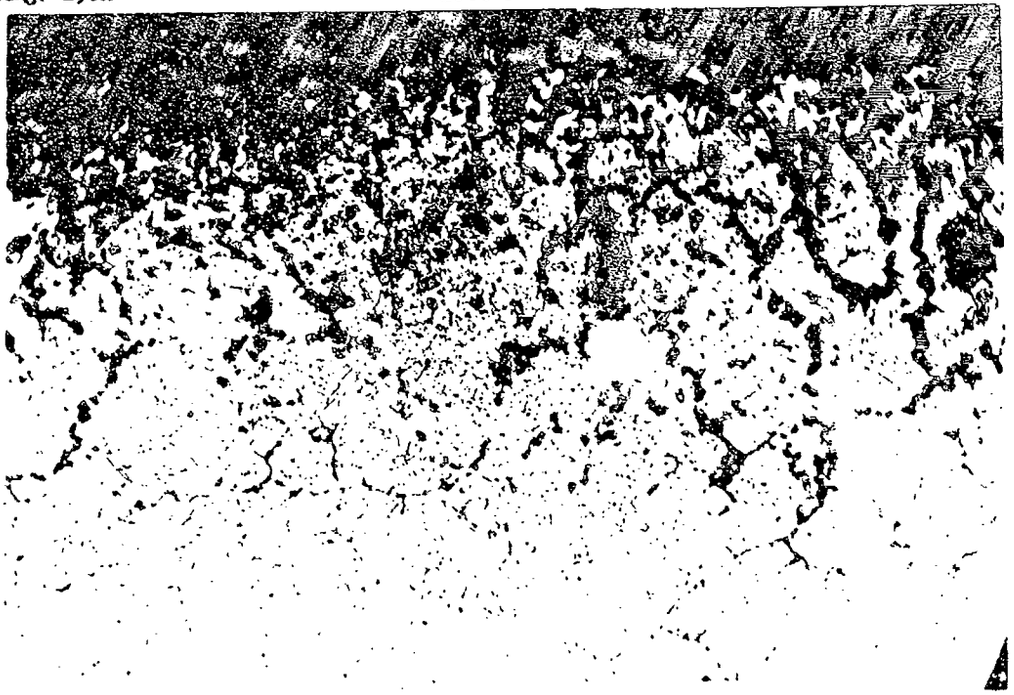
N 4313 Base Off 990 on Rastelloy X Figure 172

Mag: 250X 1800°F Etch: C



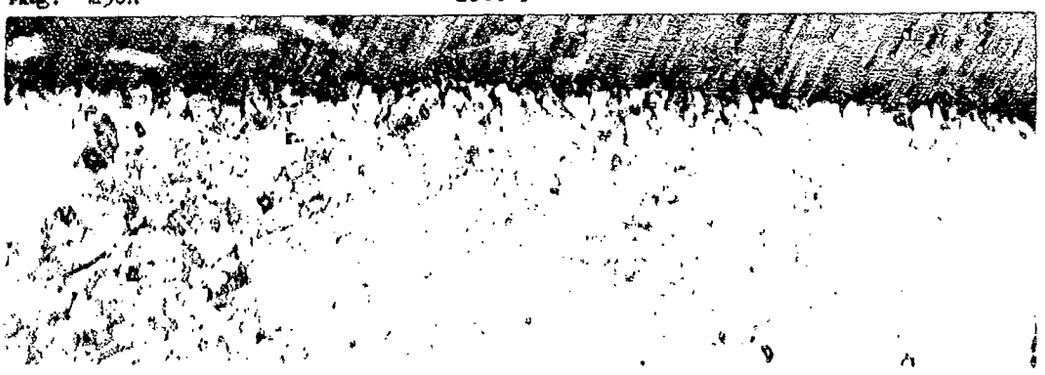
Extreme Pitting and Corrosion Attack

M 4314 Base Off 990 on 310 SS Figure 173
Mag: 250X 1800°F Etch: D



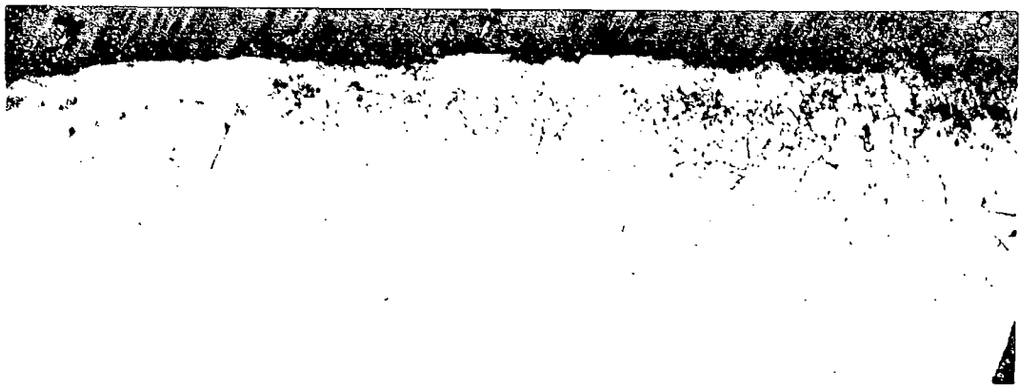
Severe Intergranular Corrosion

M 4315 Fel. Pro. 65-A Inconel X Figure 17
Mag: 250X 1800°F Etch: A

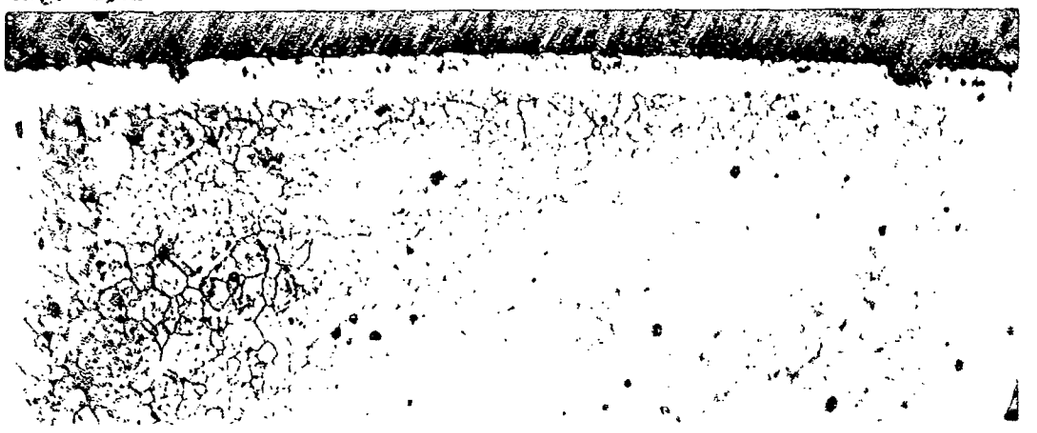


Intergranular Oxidation

M 4316 Fel. Pro. 65-A on A-286 Figure 175
Mag: 250X 1800°F Etch: B



M 4317 Fel. Pro. 65-A on René-41 Figure 176
Mag: 250X 1800°F Etch: C

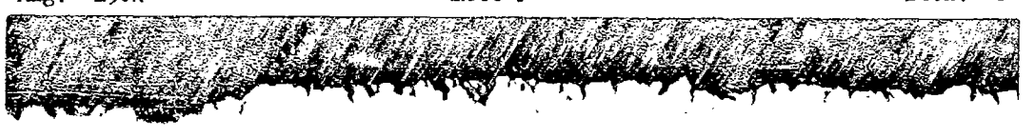


Oxidation

M 4318 | Fel. Pro. 65-A on L-605 | Figure 177
Mag: 250X | 1800°F | Etch: C

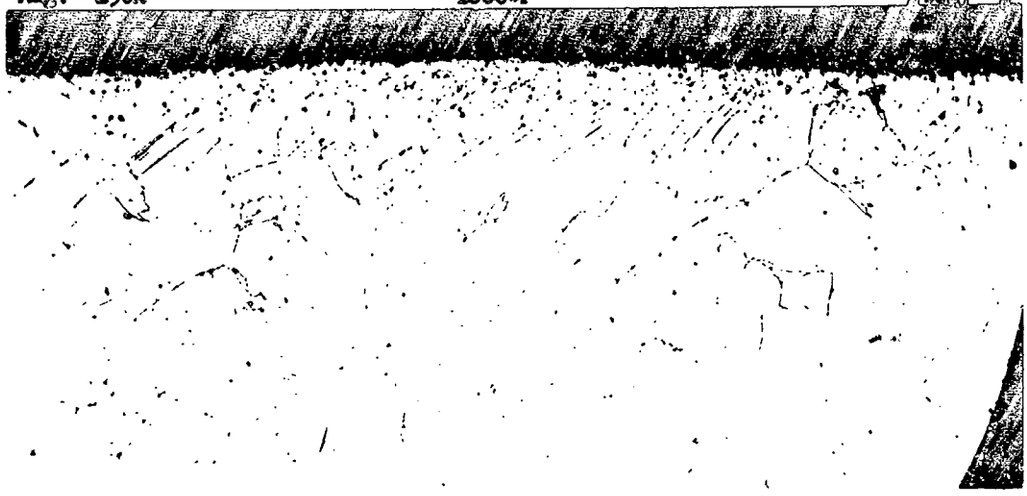
Oxidation

M 4319 | Fel. Pro. 65-A on Hastelloy X | Figure 178
Mag: 250X | 1800°F | Etch: C

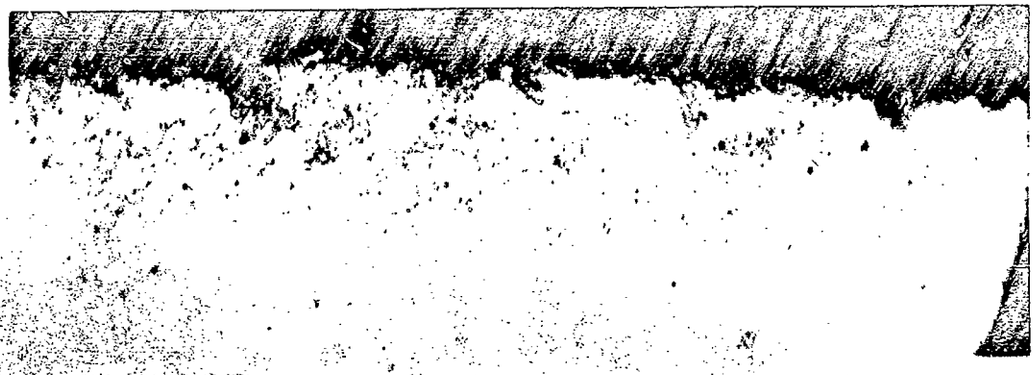


Oxidation and Slight Pitting

M 4320 Fel. Pro. 65-A on 310 SS Figure 179
Mag: 250X 1800°F Etch: D



M 4321 DGF 123 on Inconel X Figure 180
Mag: 250X 1800°F Etch: A

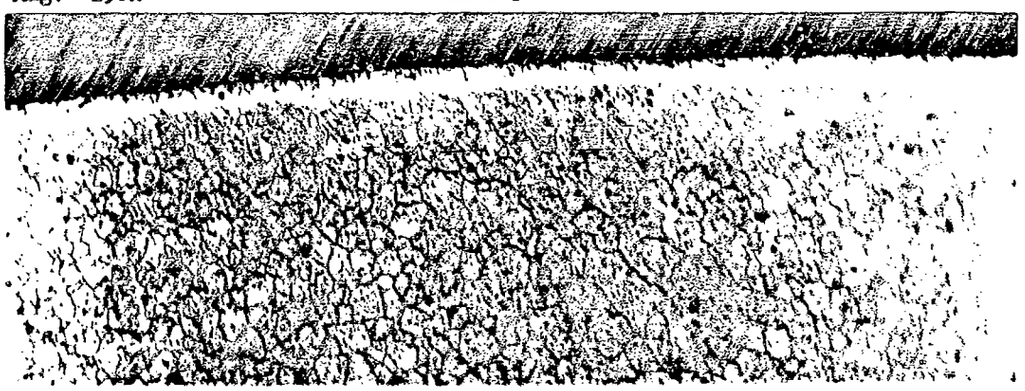


Oxidation

M 4322 | DGF 123 on A-286 | Figure 181
Mag: 250X | 1800°F | Etch: B

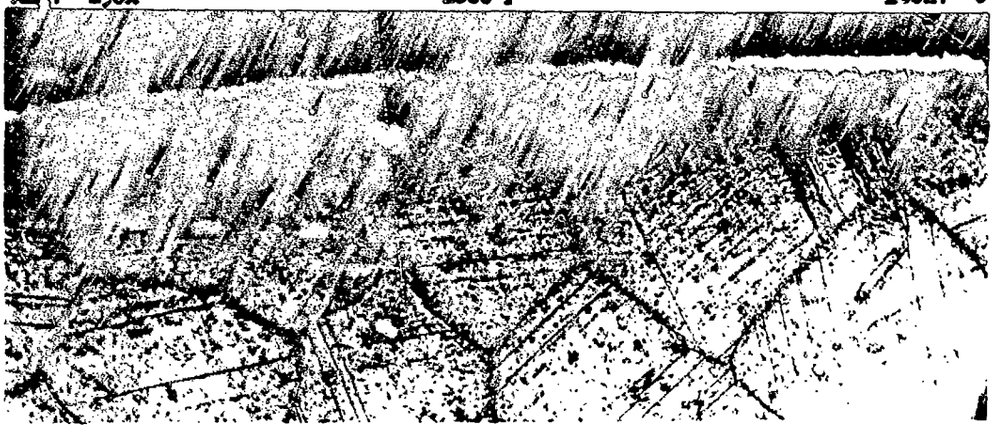
Scale Oxidation

M 4323 | DGF 123 on René-41 | Figure 182
Mag: 250X | 1800°F | Etch: C



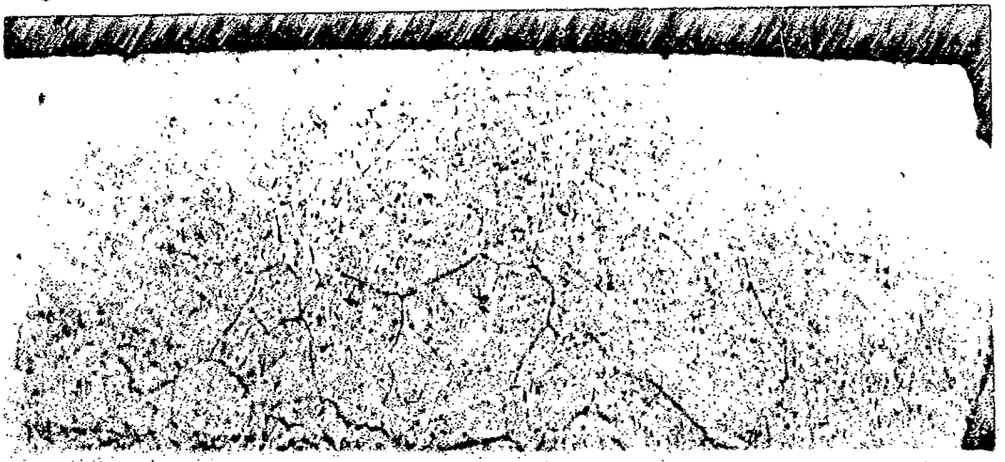
Film and Slight Intergranular Oxidation

M 4324 DGF 123 on L-605 Figure 183
Mag: 250X 1800°F Etch: C



Oxidation

M 4325 DGF 123 on Hastelloy X Figure 184
Mag: 250X 1800°F Etch: C



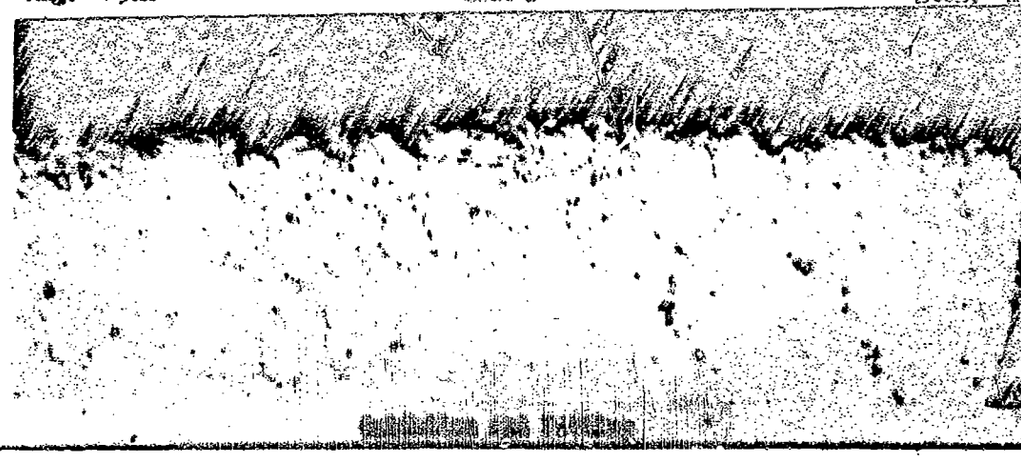
M 4326 | NF 123 on 310 SS | Figure 185
Mag: 250X | 1800°F | Etch: D

Oxidation

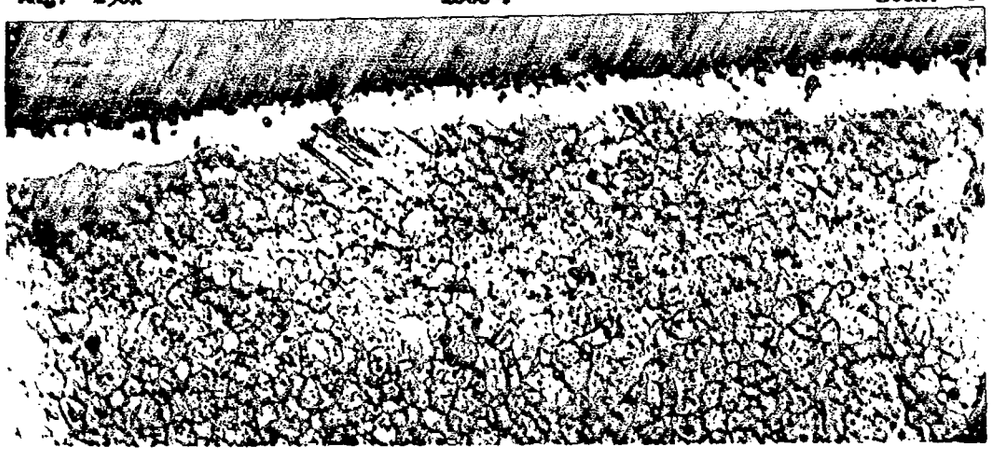
M 4327 | MIL-T-5544A on Inconel X | Figure 186
Mag: 250X | 1800°F | Etch: A

Oxidation

M 4328 | MIL-T-5544A on A-286 | Figure 187
Mag: 250X | 1200°F | Etch: D

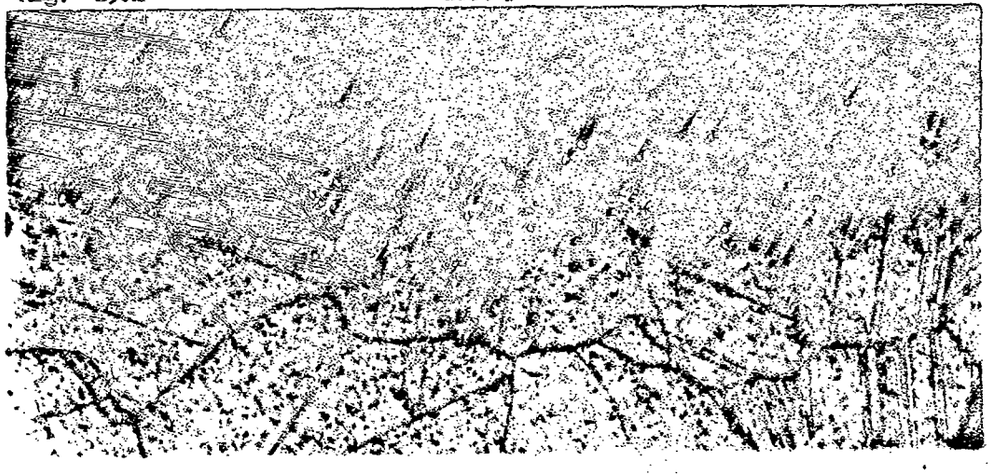


M 4329 MIL-T-5544A on Rene'-41 Figure 168
Mag: 250X 1800°F Etch: C

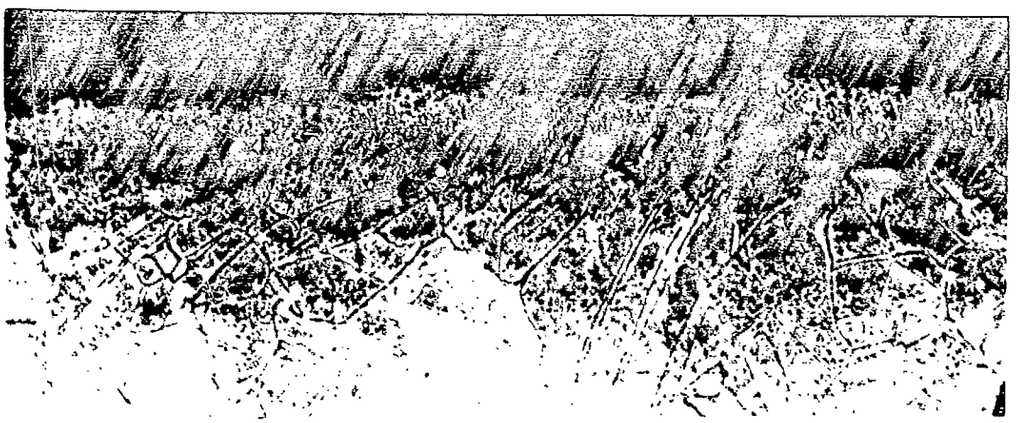


Oxidation and Slight Pitting

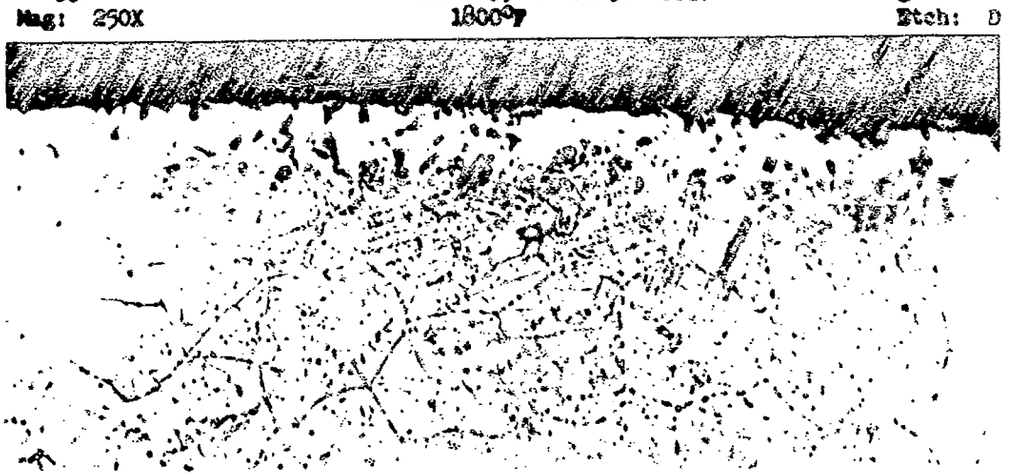
M 4330 MIL-T-5544A on L-605 Figure 169
Mag: 250X 1800°F Etch: C



N 4331 MIL-T-5544A on Hastelloy X Figure 190
Mag: 250X 1800°F Etch: C

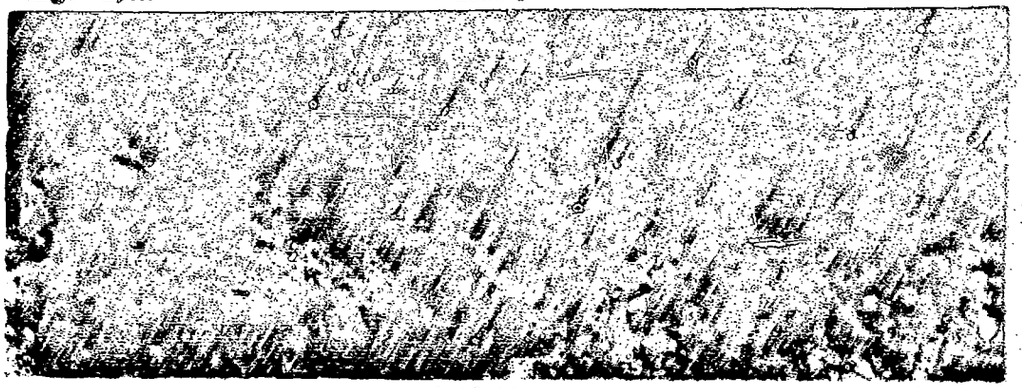


N 4332 MIL-T-5544A on 310 S.S. Figure 191
Mag: 250X 1800°F Etch: D



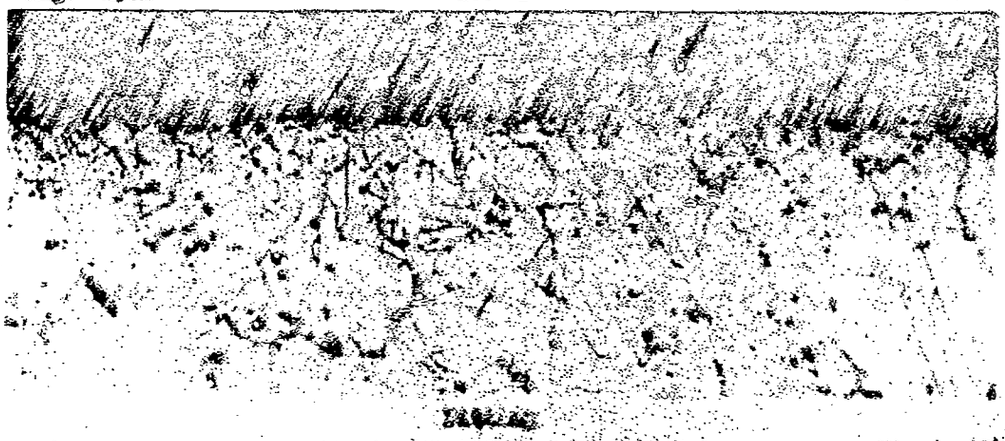
Intergranular Attack

N 4333 — Electrofilm 1000 on Inconel X — Figure 192
Mag: 250X — 1800°F — Etch: A

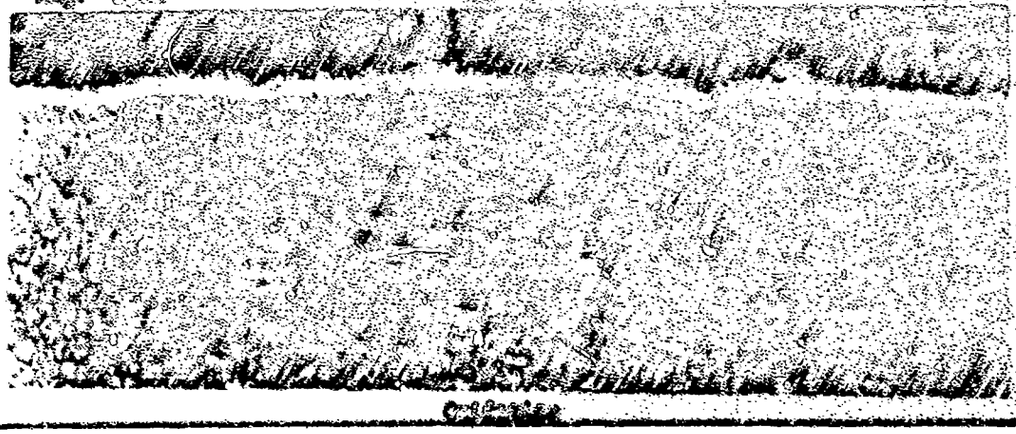


Orientation

N 4334 — Electrofilm 1000 on A-286 — Figure 193
Mag: 250X — 1800°F — Etch: B



N 4335 — Electrofilm 1000 on Inconel — Figure 194
Mag: 250X — 1800°F — Etch: C



Orientation

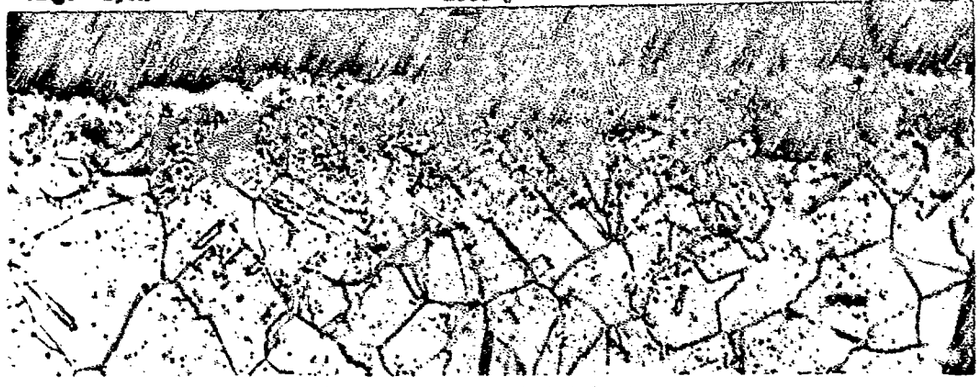
N 4336 | Electrofilm 1000 on L-605 | Figure 195
Mag: 250X | 1800°F | Etch: C

Oxidation and Slight Pitting

N 4337 | Electrofilm 1000 on Hastelloy X | Figure 196
Mag: 250X | 1800°F | Etch: C

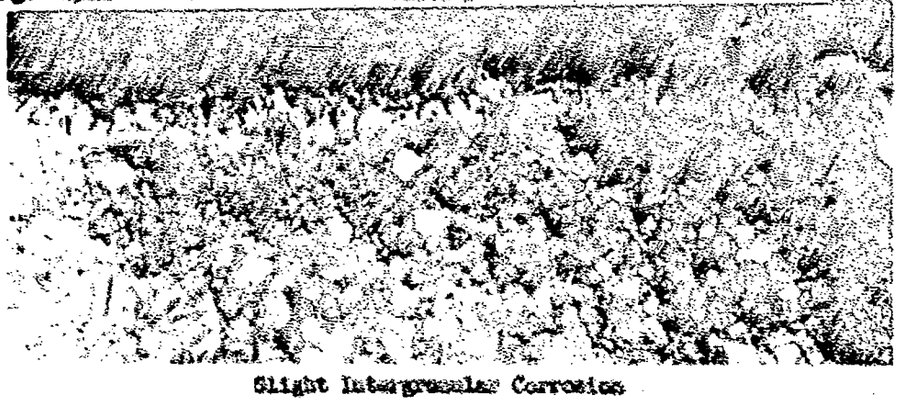
[illegible]

M 4338 Electrofilm 1000 on 310 SS Figure 197
Mag: 250X 18000Å Etch:



Slight Intergranular Attack

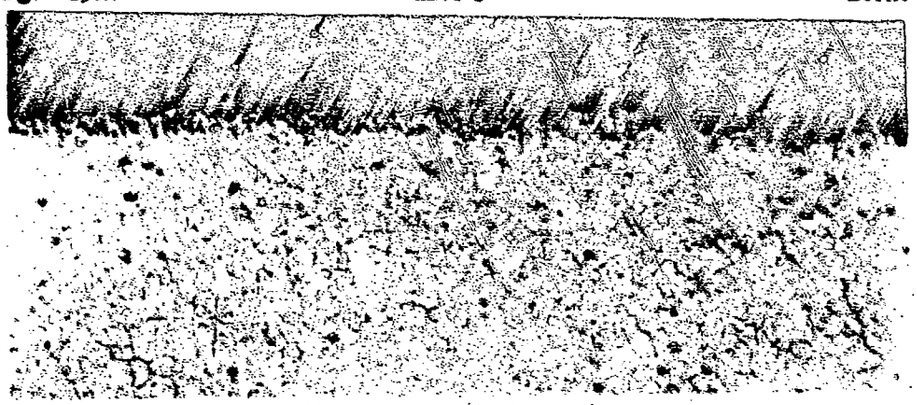
M 4339 Electrofilm 1005 on Inconel X Figure 198
Mag: 250X 18000Å Etch: A



Slight Intergranular Corrosion

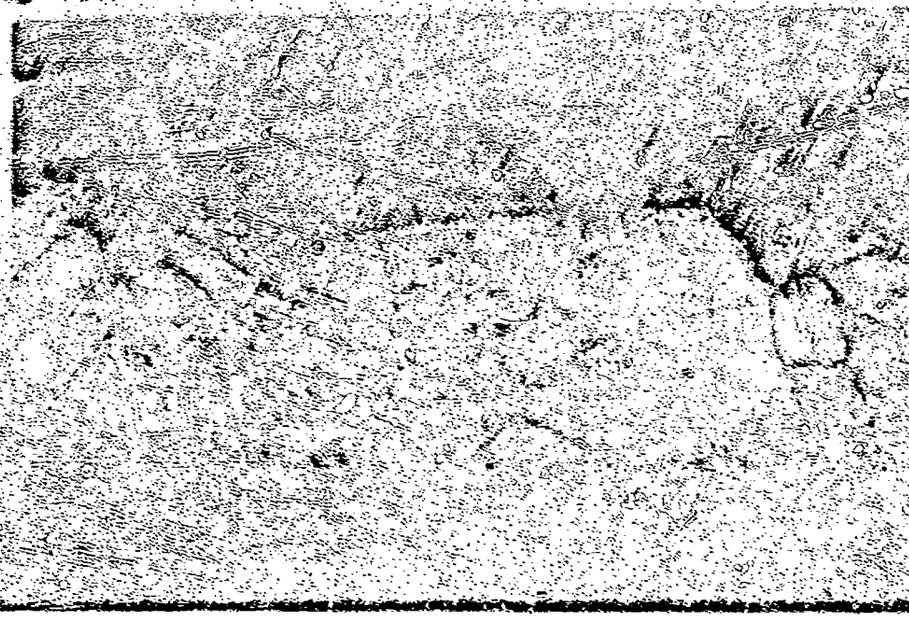
M 4340 Electrofilm 1005 on A-286 Figure 199
Mag: 250X 18000Å Etch: B

M 4341 Electrofilm 1005 on René-41 Figure 200
Mag: 250X 1200°F Etch: C

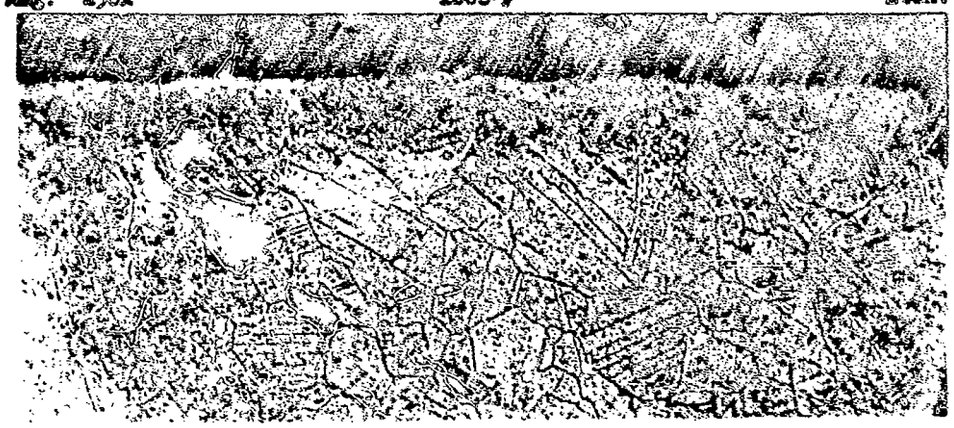


Oxidation and Slight Pitting

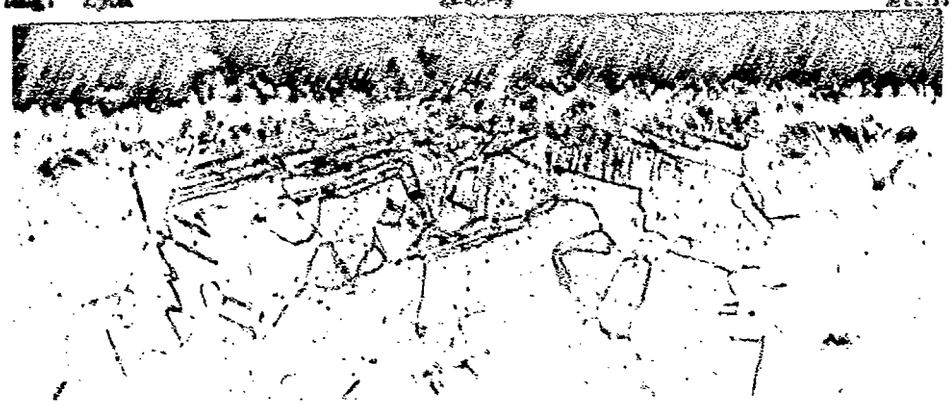
M 4342 Electrofilm 1005 on René-41 Figure 201
Mag: 250X 1200°F Etch: C



M 4343 Electrofilm 1005 on Hastelloy X Figure 202
Mag: 250X 150079 Etch: C



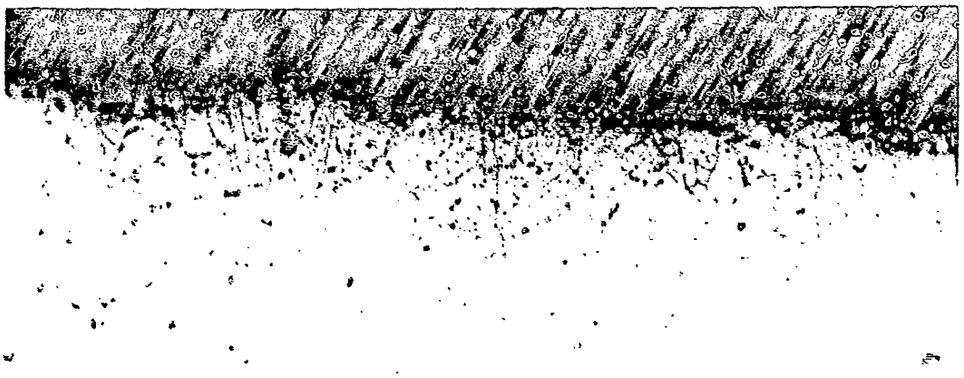
M 4344 Electrofilm 1005 on 310 SS Figure 203
Mag: 250X 150079 Etch: D



Oxidation

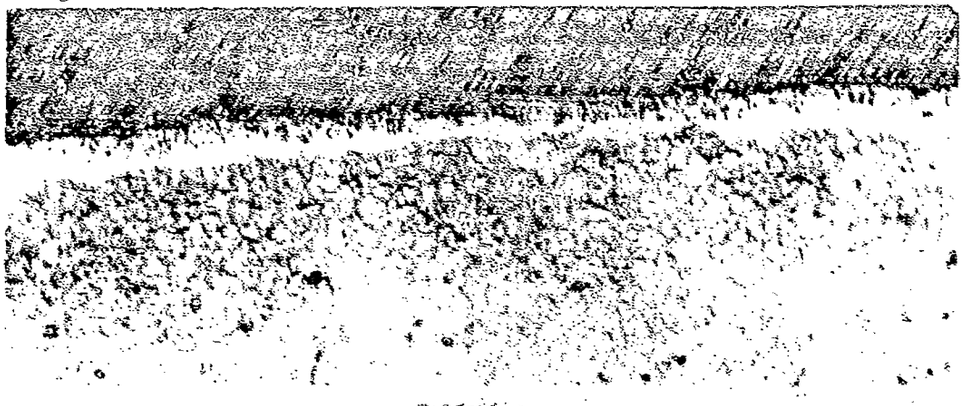
M 4349 Electrofilm [illegible] on Inconel X Figure 204
[illegible] Etch: A

M 4346 Electrofilm 800T on A-286 Figure 205
Mag: 250X 1800°F Etch: B



Intergranular Oxidation and Pitting

M 4347 Electrofilm 200T on Rend-41 Figure 206
Mag: 250X 1800°F Etch: C



Oxidation

Mag: 250X

Electrofilm 200Ŧ on L-605
1800°F

Figure 207
Etch: C

Oxidation and Pitting

M 4349
Mag: 250X

Electrofilm 200Ŧ on Hastelloy X
1800°F

Figure 208
Etch: C

Slight Oxidation

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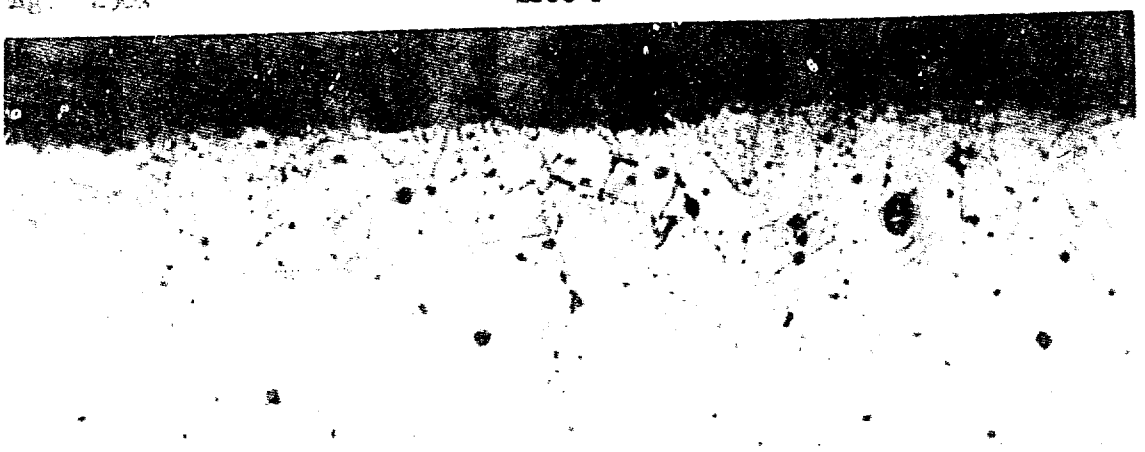
IN
ORIGINAL
DOCUMENT

M 4352
Mag: 250X

Electrofilm 66C on A-286
1800°F

Figure 211
Etch: B

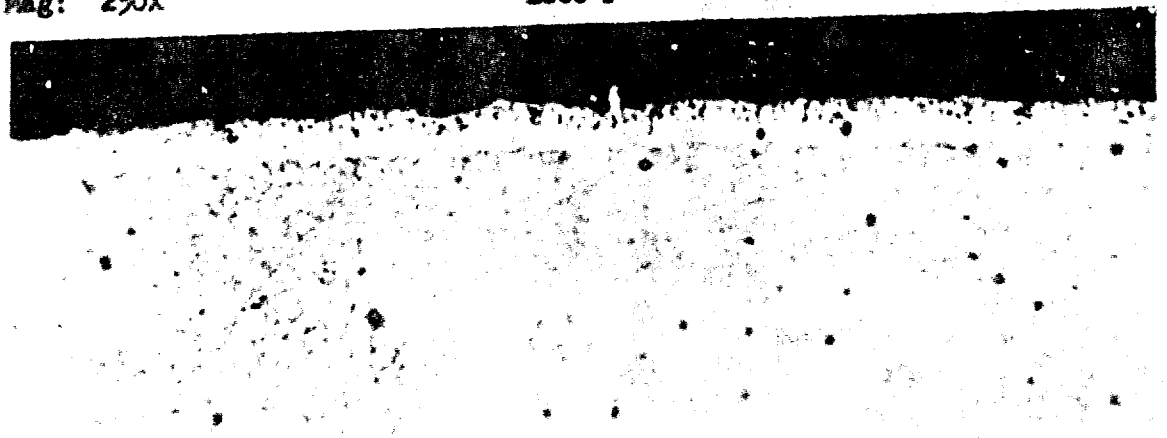


Pitting

M 4353
Mag: 250X

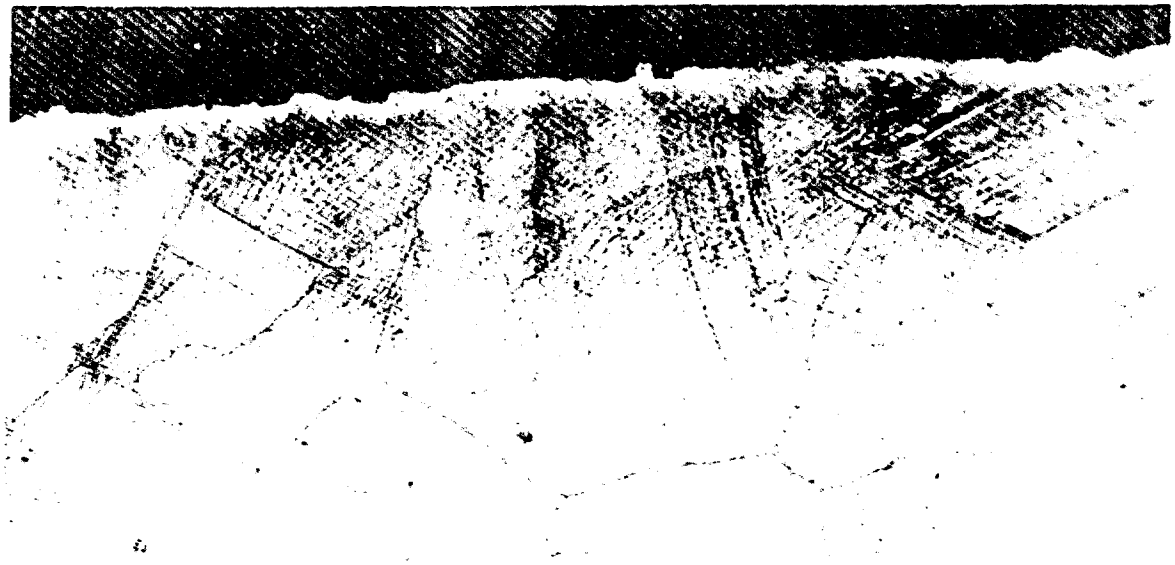
Electrofilm 66C on René-41
1800°F

Figure 212
Etch: C



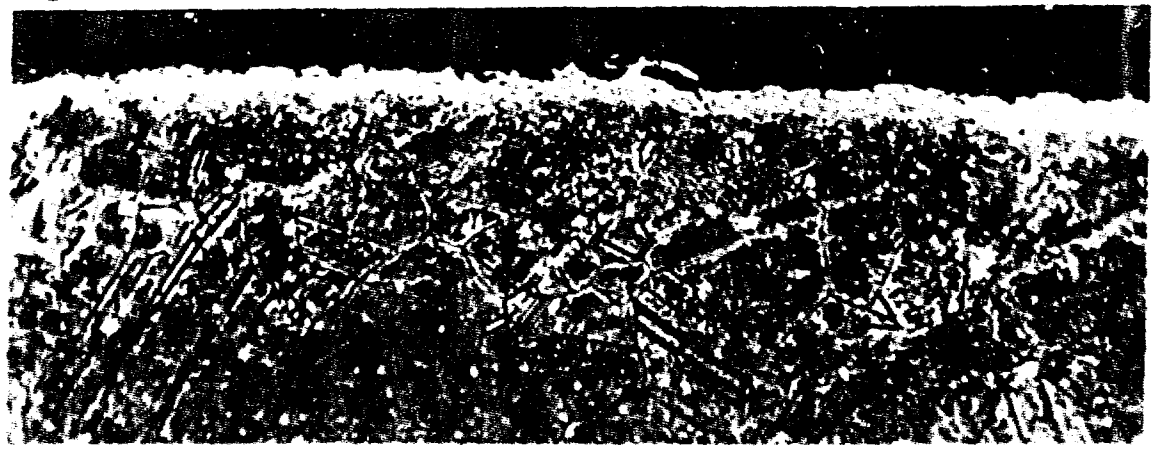
Oxidation

M 4354 Electrofilm 66C on L-605 Figure 213
Mag: 250X 1800°F Etch: C



Oxidation and Slight Pitting

M 4355 Electrofilm 66C on X Figure 214
Mag: 250X 1800°F Etch: C



Pitting

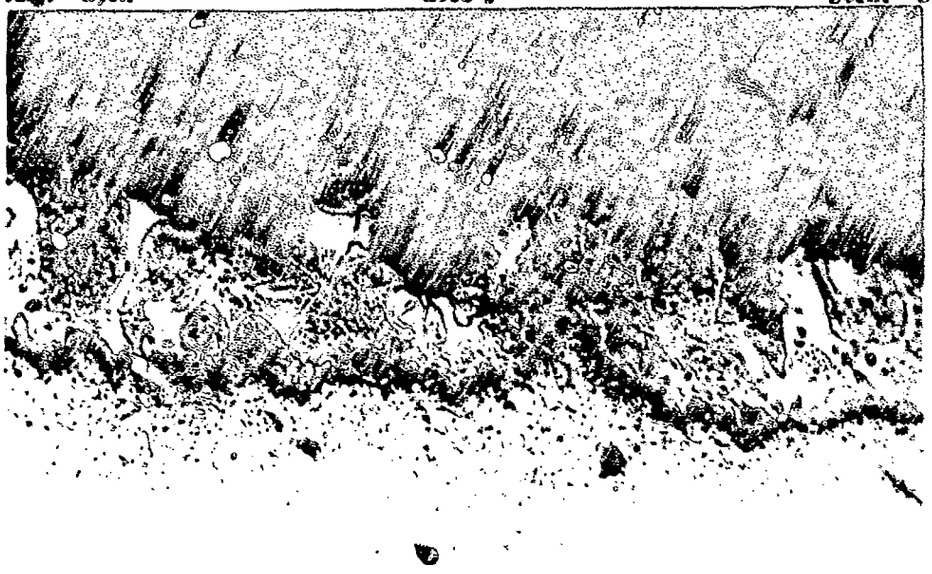
M 4358 Electrofilm 66C on 310 SS Figure 215
Mag: 250X 1800°F Etch: D

Oxidation and Slight Pitting

M 4357 Phosphatherm RM on Inconel X Figure 216
Mag: 250X 1800°F Etch: A

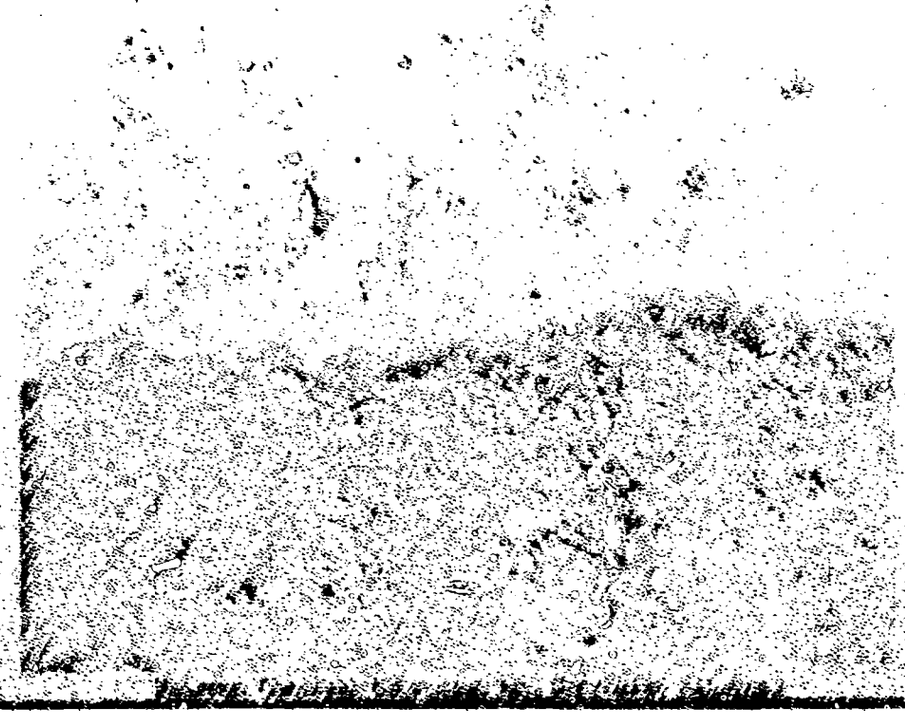
Extreme Chemical Corrosion and Pitting

M 4358 Phosphathera RM on A-286 Figure 217
Mag: 250X 180°F Etch: B

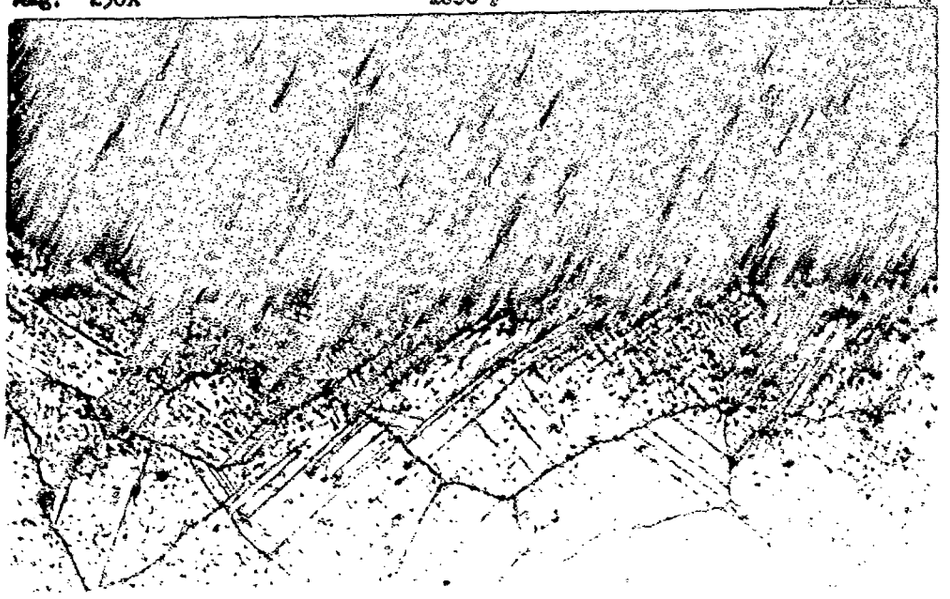


Extreme Pitting and Corrosive Alloying

M 4359 Phosphathera RM on Rene-41 Figure 218
Mag: 250X 180°F Etch: C



M 4360 Phosphathera RN on L-605 Figure 219
Mag: 250X 1800°F Etch: C

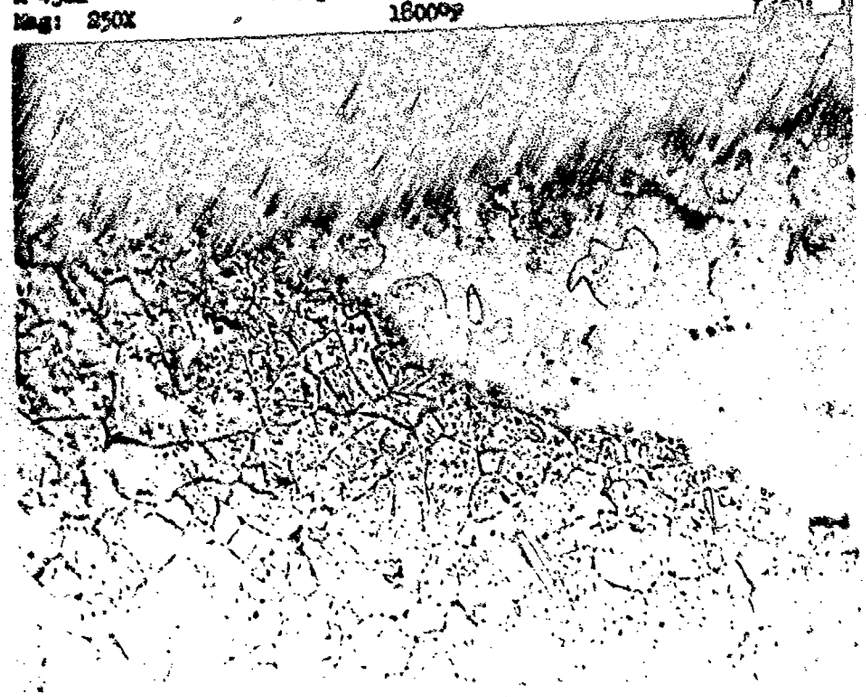


Severe Chemical Corrosion

M 4361 Phosphatherm RH on Hastelloy X Figure 220
Mag: 250X 1600°F Etch: C

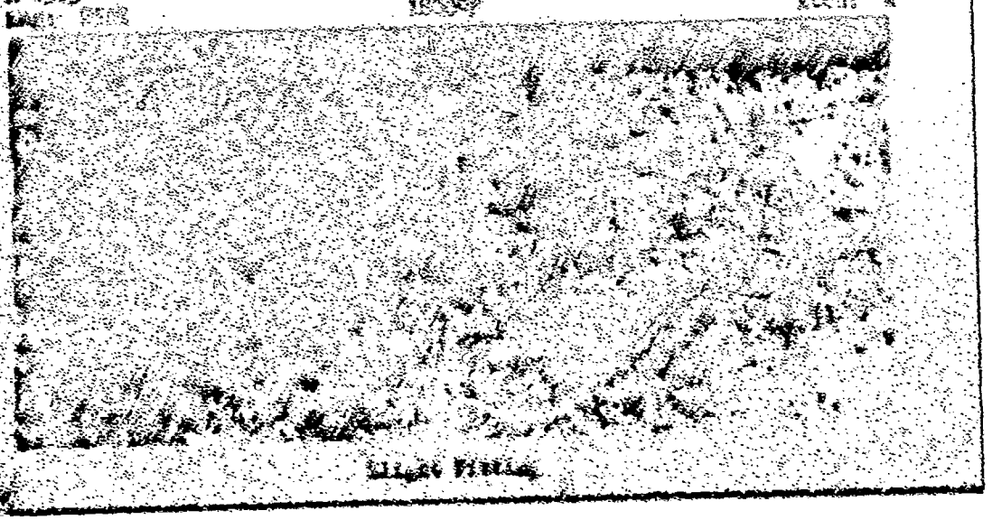
Extreme Chemical Corrosion and Corrosive Alloying

M 4362 Phosphatherm RM on 310 SS Figure 221
Mag: 250X 180009



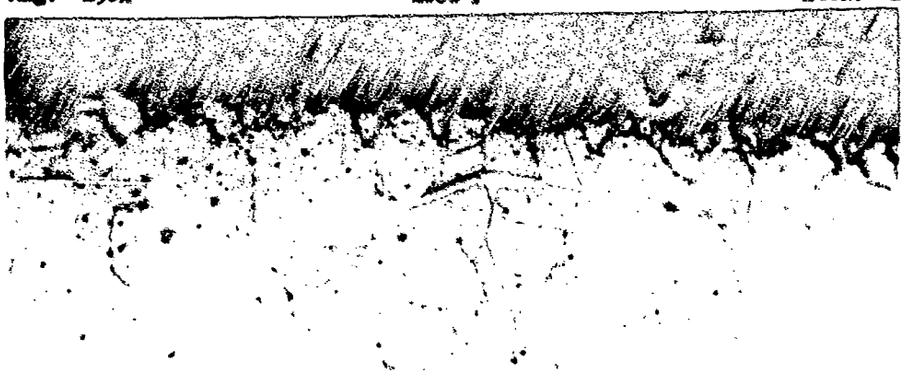
Extreme Pitting and Corrosive Alloying

M 4353 Sodium Silicate on Inconel X Figure 222
Mag: 250X 180007 Etch: A



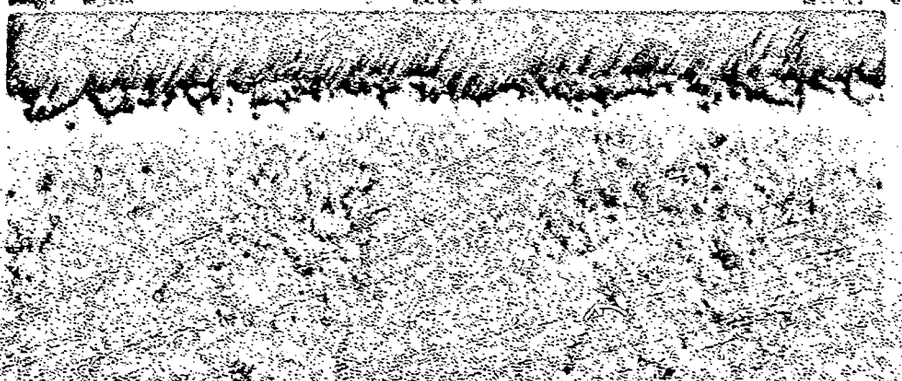
Light Pitting

M 4364 Sodium Silicate on A-286 Figure 223
Mag: 250X 180097 Etch: B

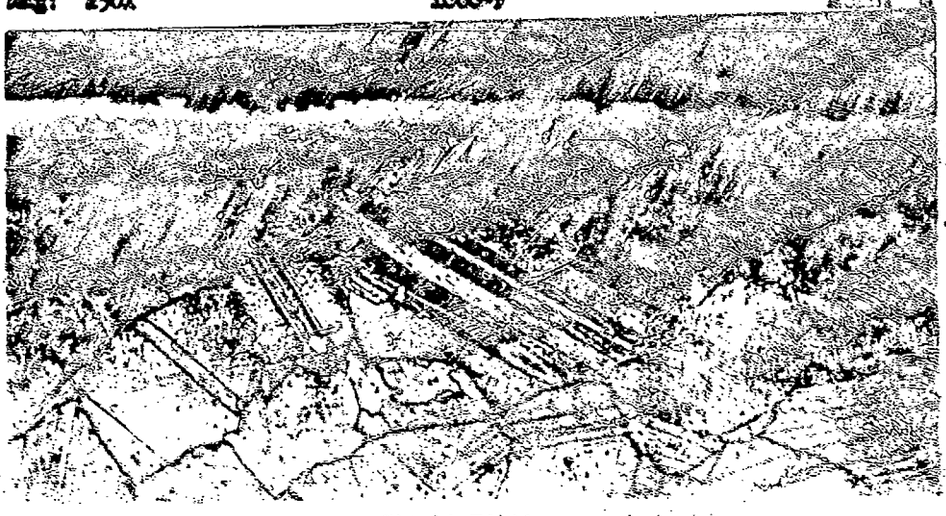


Pitting and Intergranular Attack

M 4365 Sodium Silicate on Rene-41 Figure 224
Mag: 250X 180098 Etch: C



N 4366 Sodium Silicate on L-605 Figure 823
Mag: 250X 180079



Slight Pitting

N 4367 Sodium Silicate on Rene'41 Figure 824
Mag: 250X 58

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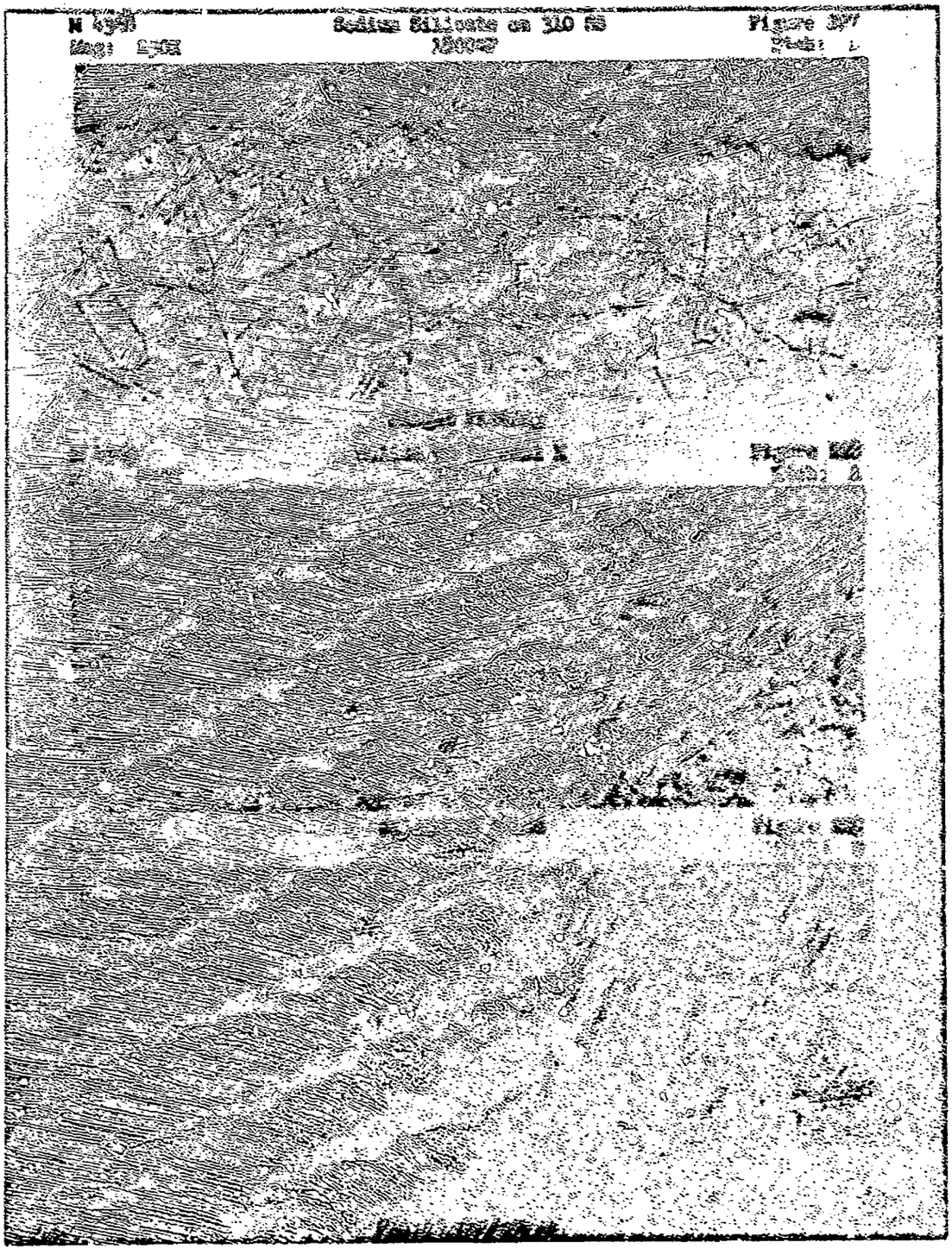
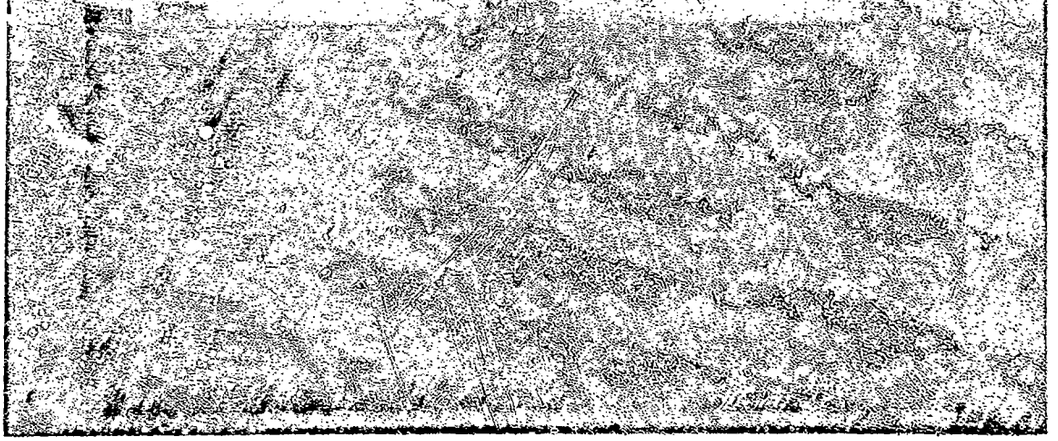


M 4371 Silica on René-41 Figure 230
Mag: 250X 180007 Etch: C

M 4372 Silica on L-605 Figure 231
Mag: 250X 180008 Etch: C

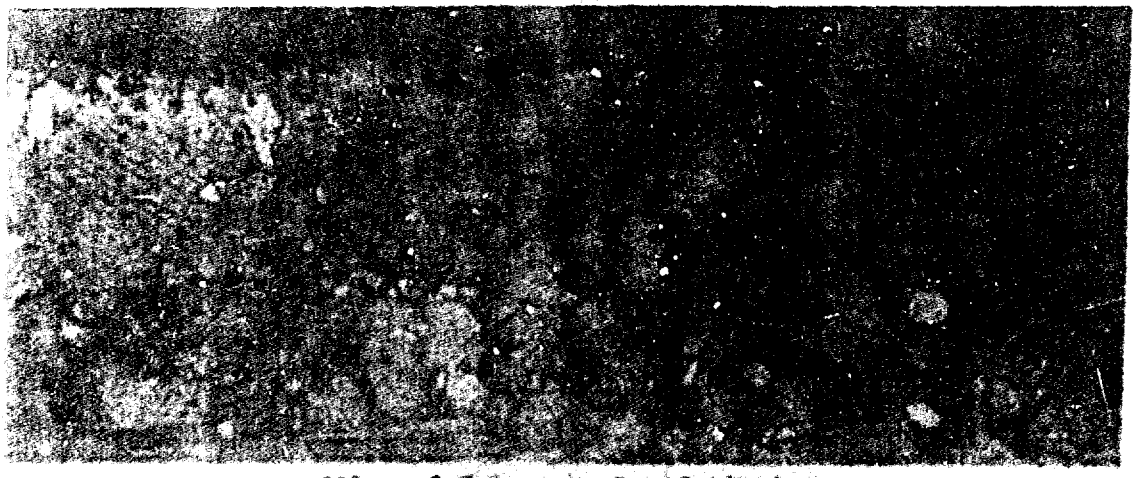
M 4373 [illegible]



Silica on 310 SS
1800°F
Figure 233
Etch: D

Slight Intergranular Attack

Milk of Magnesia on Inconel X
1800°F
Mag: 250X
Figure 234
Etch: A

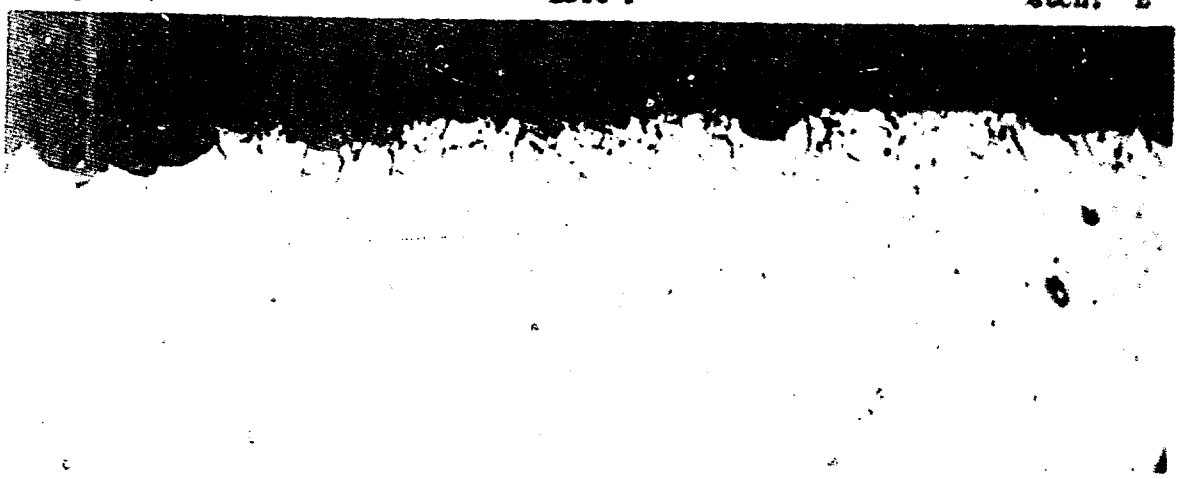


Film and Intergranular Oxidation

M [illegible]/0
Mag: 250X

Milk of Magnesia on A-286
1800°F

Figure 235
Etch: B



Pitting and Intergranular Oxidation

M 4377
Mag: [illegible]X

Milk of Magnesia on René-41
1800°F

Figure 236
Etch: C

Oxidation

M 4378
Mag: 250X

Milk of Magnesia on L-605
1800°F

Figure 237
Etch: C

M 4379
Mag: 250X

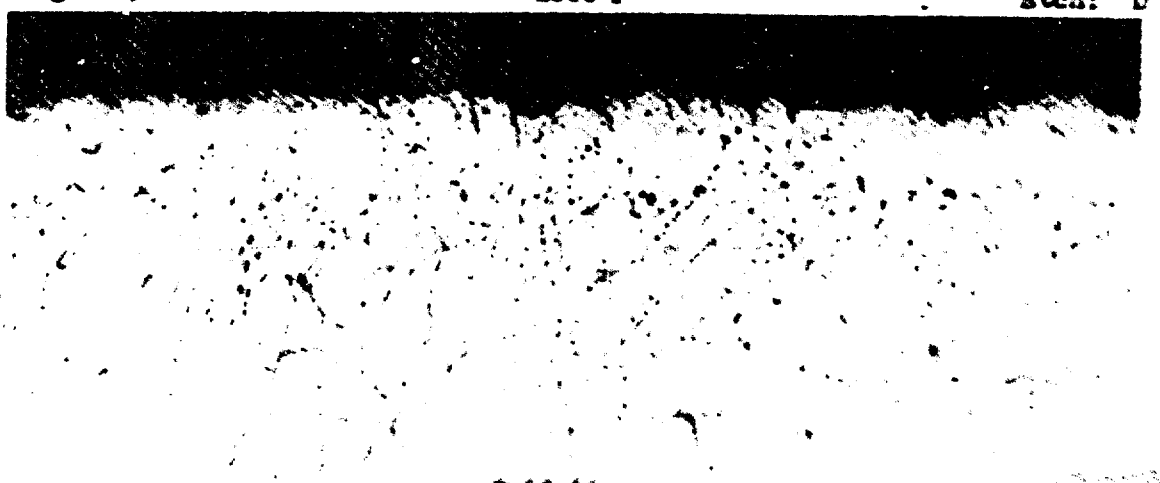
Milk of Magnesia on Hastelloy X
1800°F

Figure 238
Etch: C

M 4380
Mag: 250X

Milk of Magnesia on 310 SS
1800°F

Figure 239
Etch: D



M 4381
Mag: 250X

Magnesium Oxide on Inconel X
1200°F

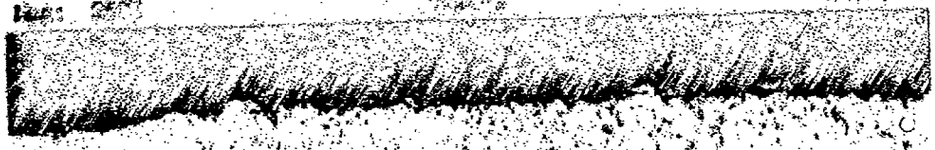
Figure 240
Etch: A

Oxidation and Pitting

M 4382
Mag: 250X

Magnesium Oxide on A-286
1200°F

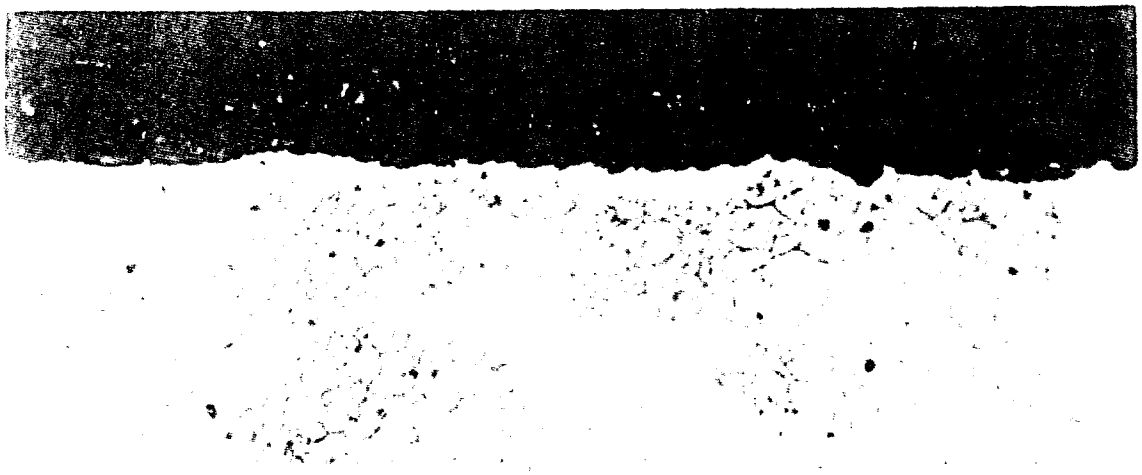
Figure 241
Etch: B



Magnesium Oxide on Rene-41
1600°F

Mag: 250X

Figure 24
Etch: C

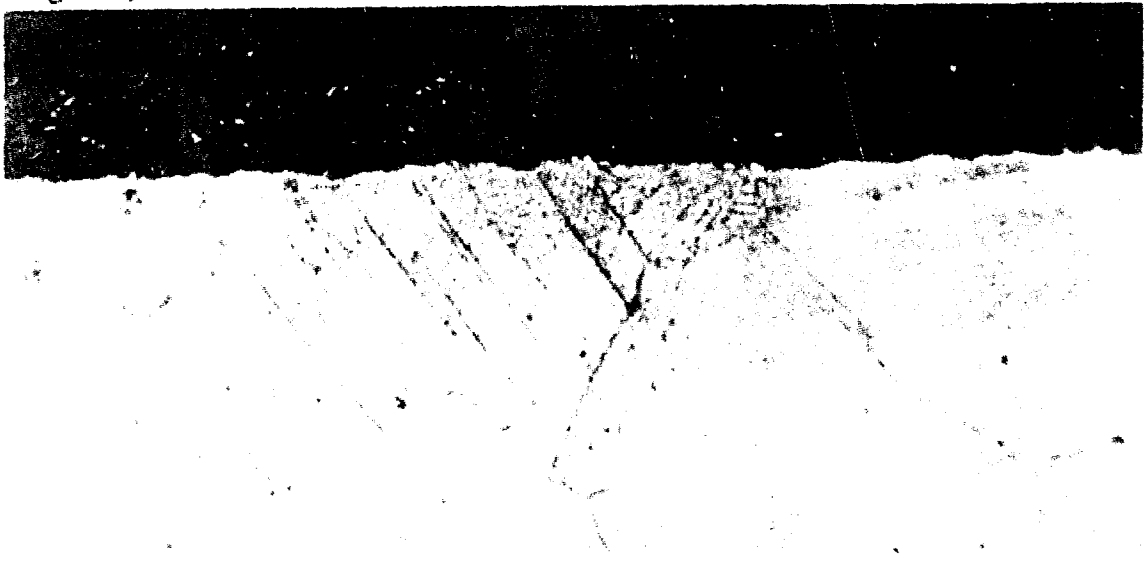


Oxidation

Magnesium Oxide on L-605
1800°F

Mag: 250X

Figure 24
Etch: C

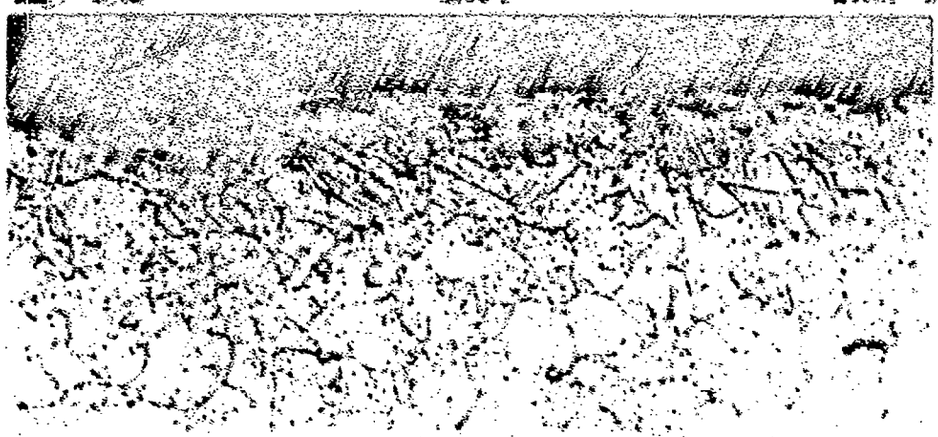


Scale Oxidation

M 4385 Magnesium Oxide on Hastelloy X Figure 244
Mag: 250X 1800°F Etch: C

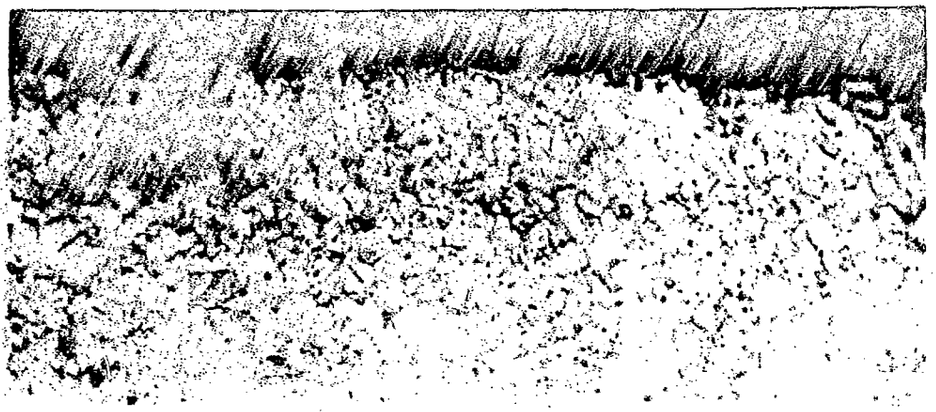
Single Oxidation

M 4336 Magnesium Oxide on 310 SS Figure 245
Mag: 250X 1800°F Etch: D



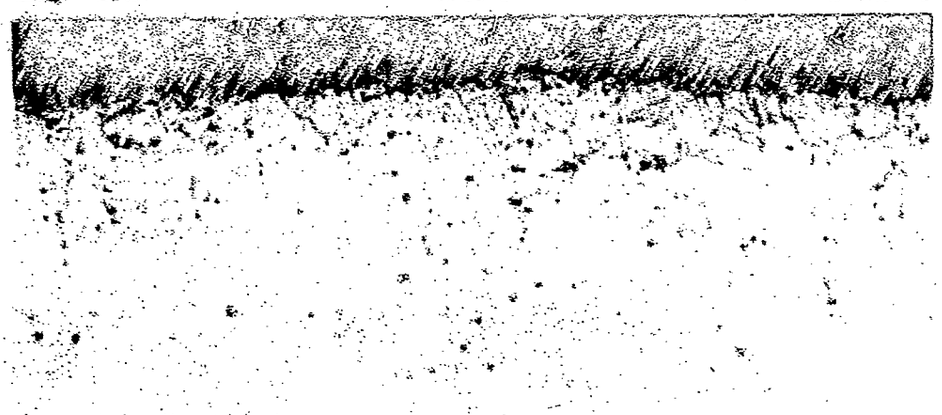
Oxidation

M 4367 Boron Nitride on Inconel X Figure 246
Mag: 250X 1800°F Etch: A



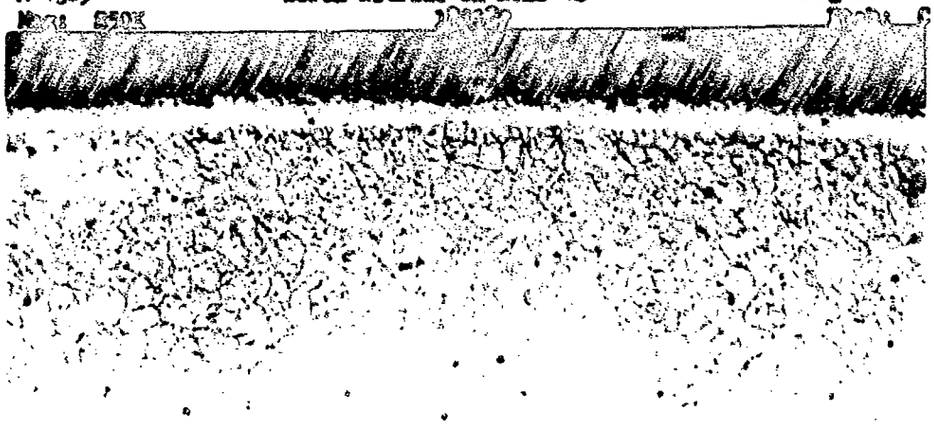
Oxidation

M 4368 Boron Nitride on A-286 Figure 247
Mag: 250X 1800°F Etch: B



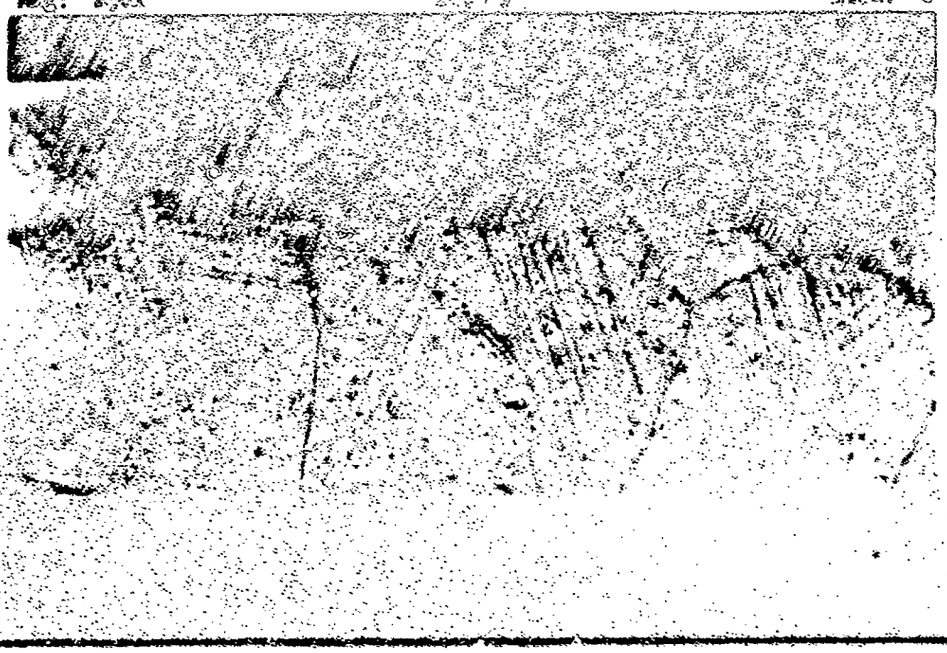
Oxidation

M 4389 Boron Nitride on Rene'-41 Figure 248
Mag: 250X Etch: C

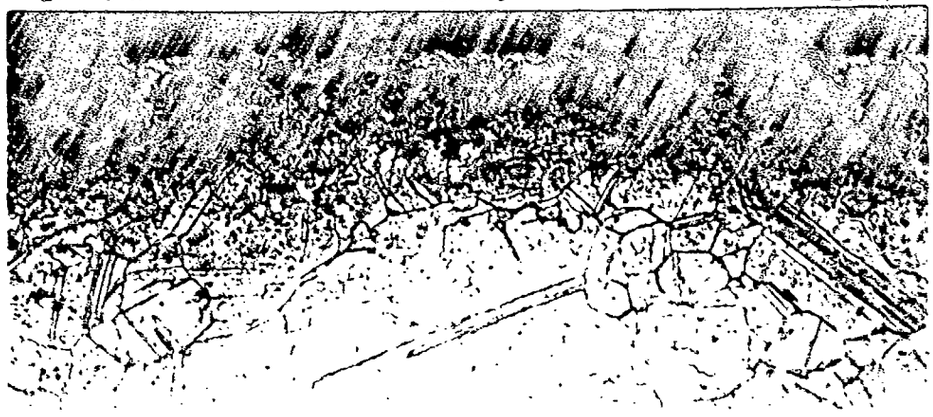


Oxidation

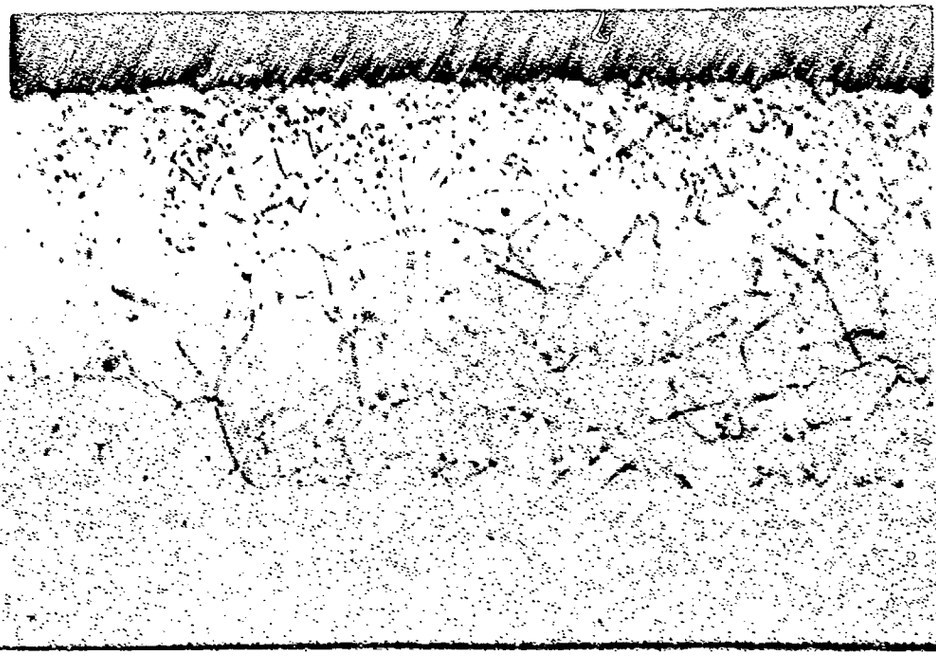
M 4390 Boron Nitride on L-605 Figure 249
Mag: 250X Etch: C



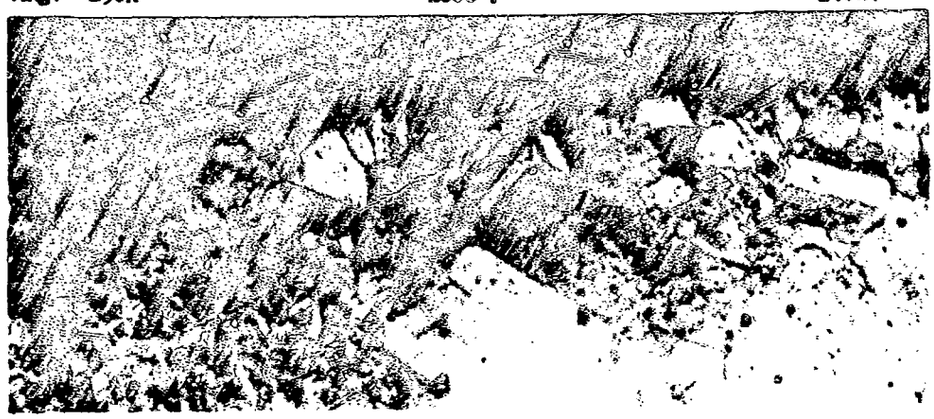
M 4391 Boron Nitride on Hastelloy X Figure 250
Mag: 250X 1800°F Etch: C



M 4392 Boron Nitride on 310 SS Figure 251
Mag: 250X 1800°F Etch: D



M 4393 Boric Oxide on Inconel X Figure 252
Mag: 250X 1800°F Etch: A



Intergranular Oxidation

M 4394 Boric Oxide on A-286 Figure 253
Mag: 250X 1800°F Etch: D

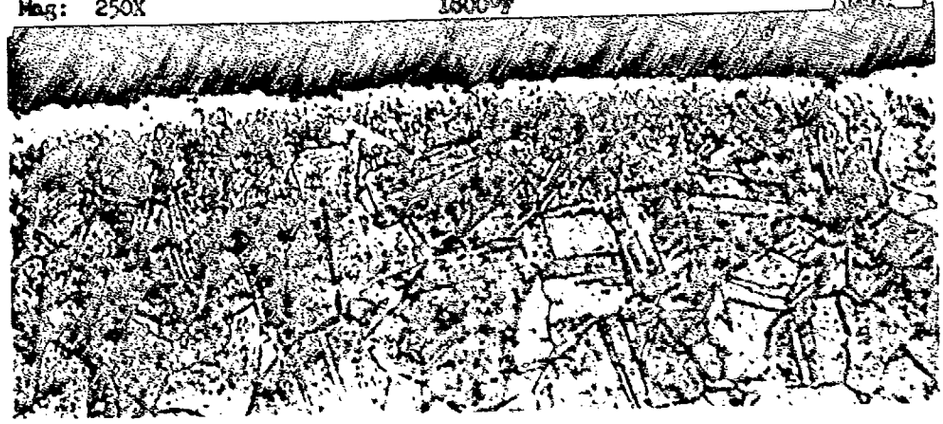
Oxidation

M 4395 Boric Oxide on Rene-41 Figure 254
Mag: 250X 1800°F Etch: C

M 4396 Boric Oxide on L-605 Figure 25
Mag: 250X 1800°F Etch:

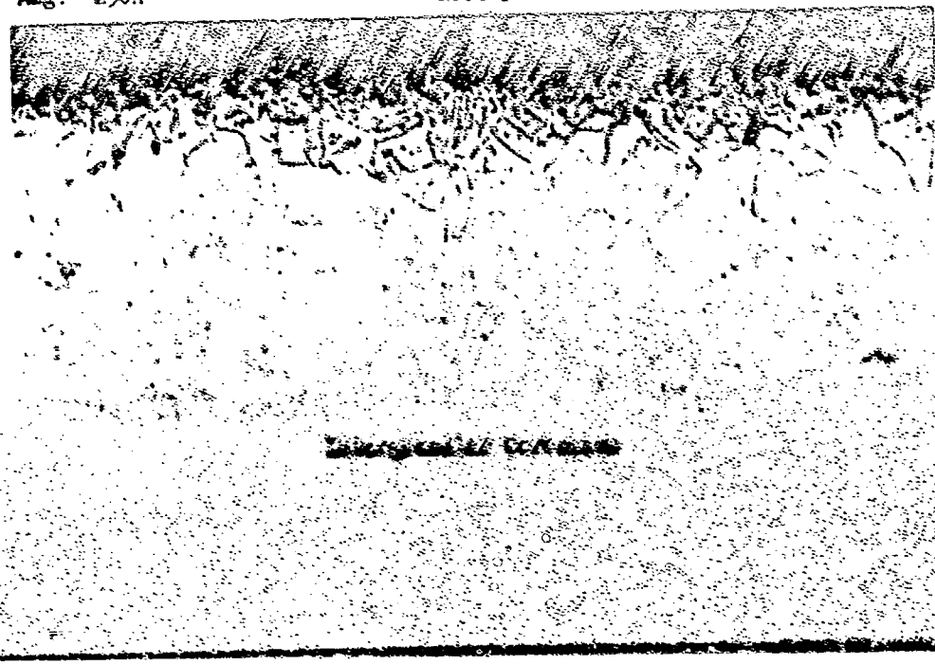
M 4397 Boric Oxide on Hastelloy X Figure 256

Mag: 250X 1800°F Etch: C



M 4398 Boric Oxide on 310 SS Figure 257

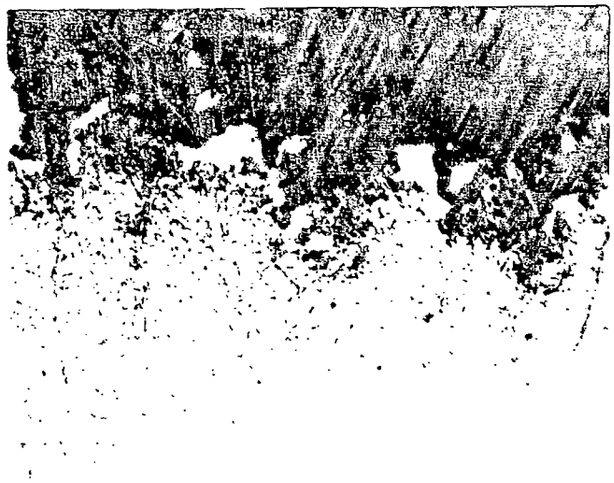
Mag: 250X 1800°F Etch: D



M 4399 Molykote X-10[illegible] on Inconel X Figure 258
Mag: 250X [illegible]800°F Etch: A

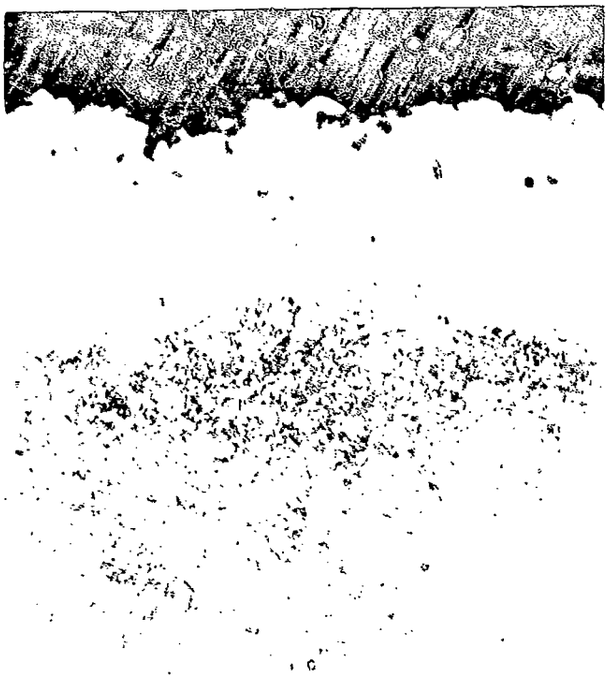
Intergranular Attack

M 4400 Molykote X-106 on A-286 Figure 259
Mag. 250X 180097 Etch: B



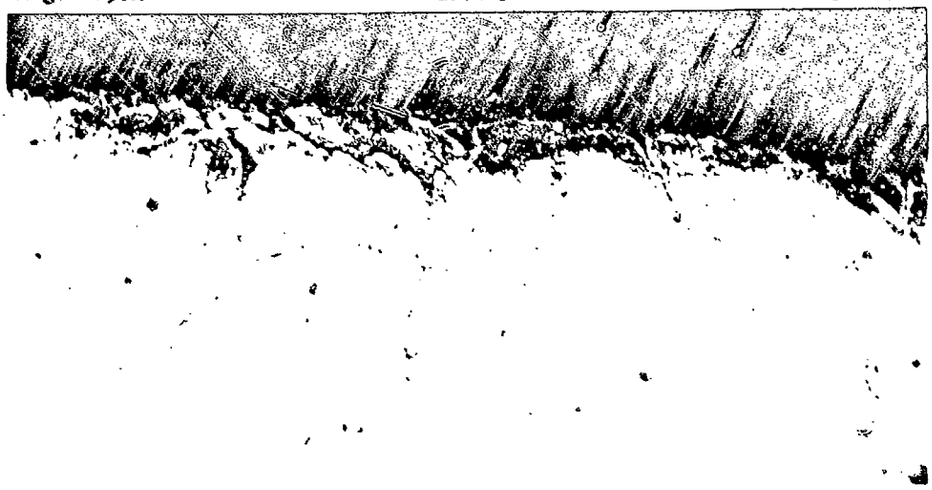
Severe Pitting

M 4401 Molykote X106 on Rene 41 Figure 260
Mag: 250X 1800°F Etch: C



Pitting and Chemical Corrosion

M 4402 Molykote X-106 on L-605 Figure 261
Mag: 250X 1800°F Etch: C



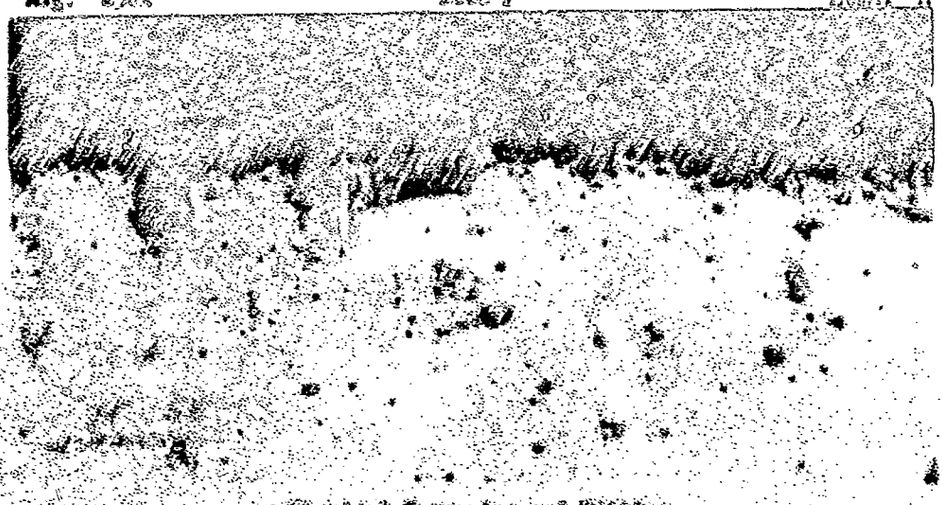
Intergranular Attack

M 4403 Molykote X-106 on Hastelloy X Figure 262
Mag: 250X 1800°F Etch: C

M 4404 Hoskyrote X-106 on 310 SS Figure 263
Mag: 250X 1800°F Etch: D

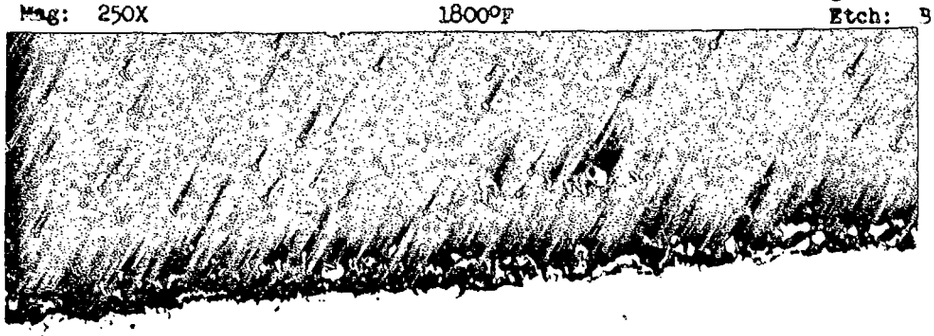
Intergranular Corrosion

M 4405 Lead Monoxide on Inconel X Figure 264
Mag: 250X 1800°F Etch: A



General Corrosion and Pitting

M 4406 Lead Monoxide on A-286 Figure 265
Mag: 250X 1800°F Etch: B

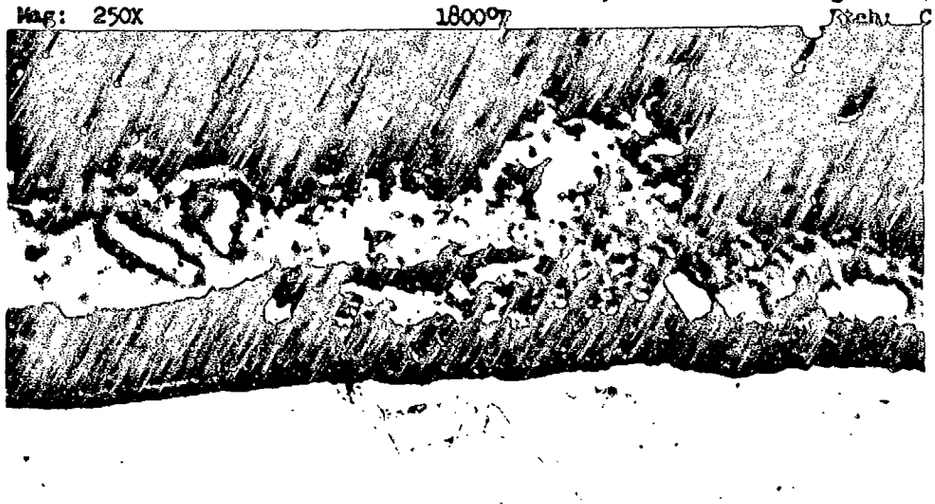


Oxidation and Pitting

M 4407 Lead Monoxide on René-41 Figure 266
Mag: 250X 1800°F Etch: D

Chemical Corrosion

M 4408 Lead Monoxide on L-605 Figure 267
Mag: 250X 1800°F Etch: C

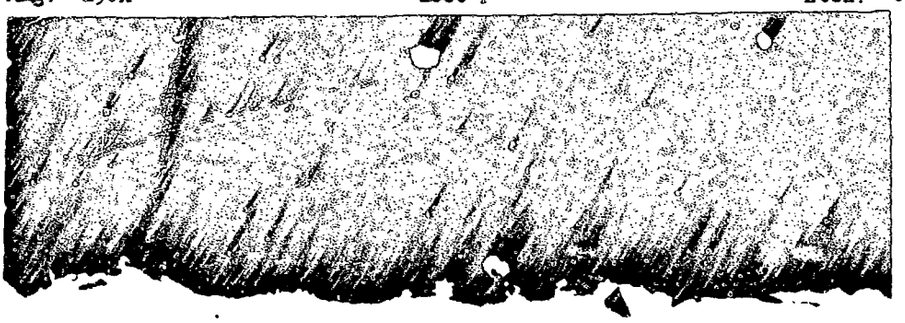


Scale Oxidation

M 4409 Lead Monoxide on Hastelloy X Figure 268
Mag: 250X 1800°F Etch: C

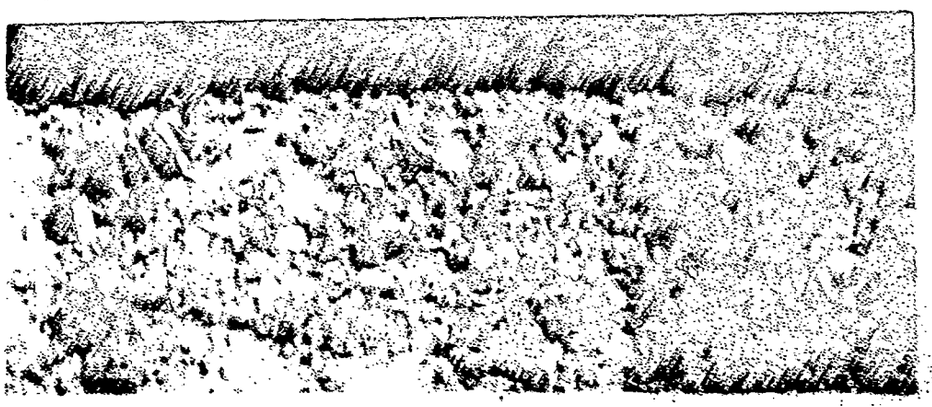
Oxidation

M 4410 Lead Monoxide on 310 SS Figure 269
Mag: 250X 1800°F Etch. C



Oxidation and Pitting

M 4411 Calcium Fluoride on Inconel X Figure 270
Mag: 250X 1600°F Etch: A

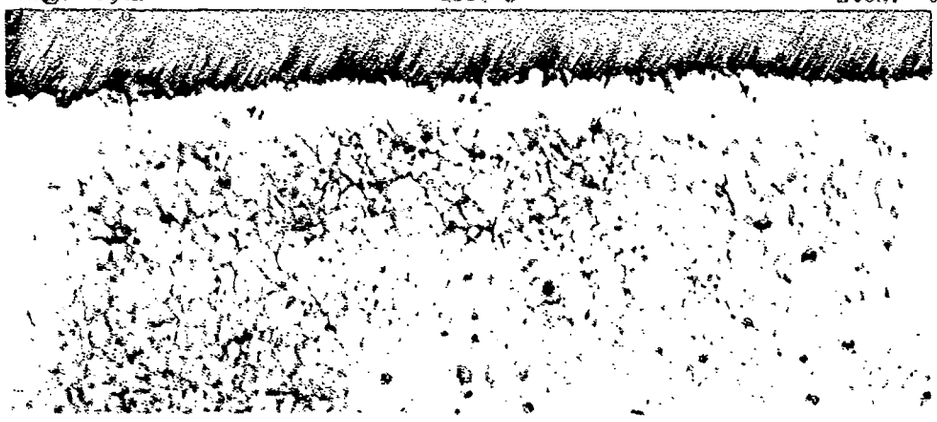


Pitting

N 4412 Calcium Fluoride on A-286 Figure 271
Mag: 250X 1800°F Etch: B

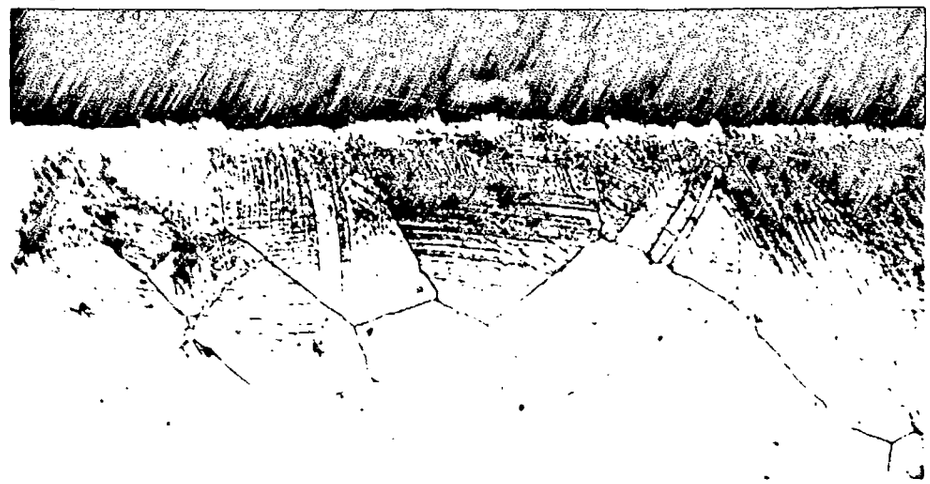
Pitting and Intergranular Oxidation

N 4413 Calcium Fluoride on René-41 Figure 272
Mag: 250X 1800°C Etch: C



Scale Oxidation

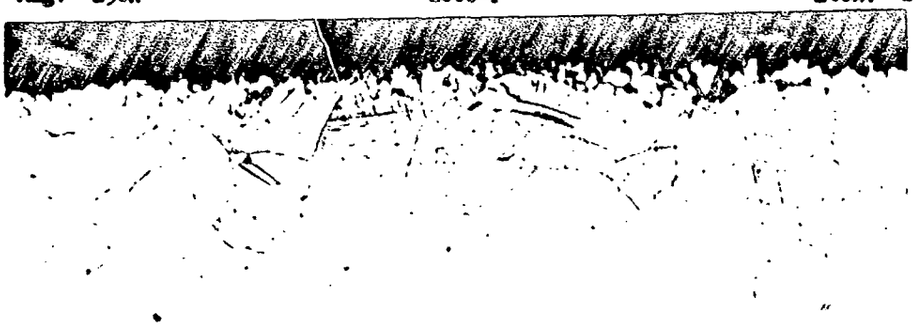
M 4414 Calcium Fluoride on L-605 Figure 273
Mag: 250X 1800°F Etch: C



Scale Oxidation

M 4415 Calcium Fluoride on Hastelloy X Figure 274
Mag: 250X 1800°F Etch: C

M 4416 Calcium Fluoride on 310 SS Figure 275
Mag: 250X 1800°F Etch: D

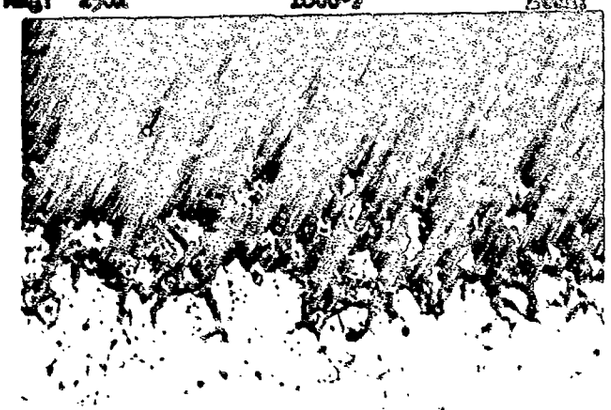


Intergranular Oxidation

M 4417 Lead Sulfide on Inconel X Figure 276
Mag: 250X 1800°F Etch: A

Extreme Corrosive Alloying

M 4418 Lead Sulfide on A-286 Figure 277
Mag: 250X 13000? Etch: B

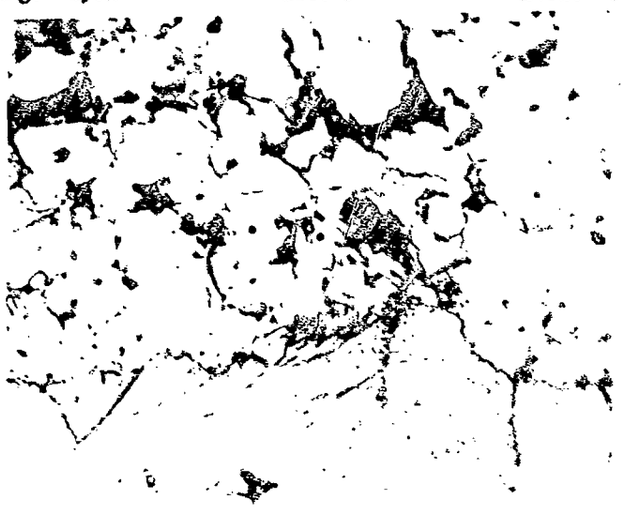


Extreme Corrosive Alloying

M 4419 Lead Sulfide on René-41 Figure 270
Mag: 250X 1800°F Etch: C

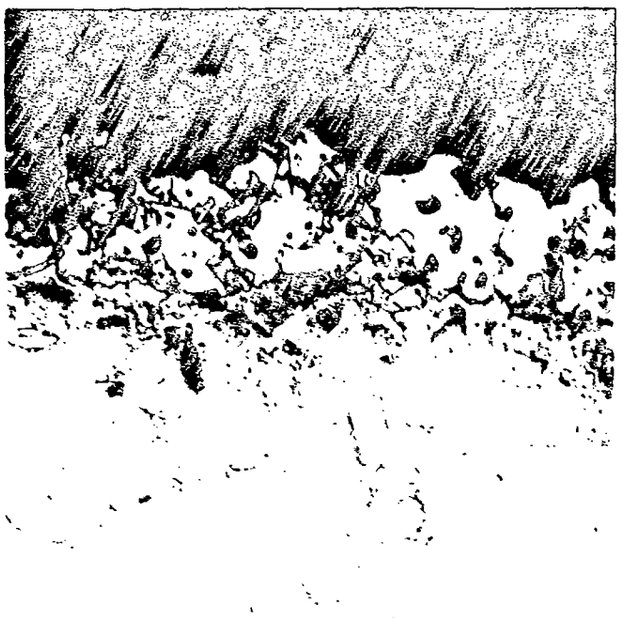
Extreme Corrosive Alloying

M 4420 Lead Sulfide on L-605 Figure 279
Mag: 250X 1800°F Etch: C



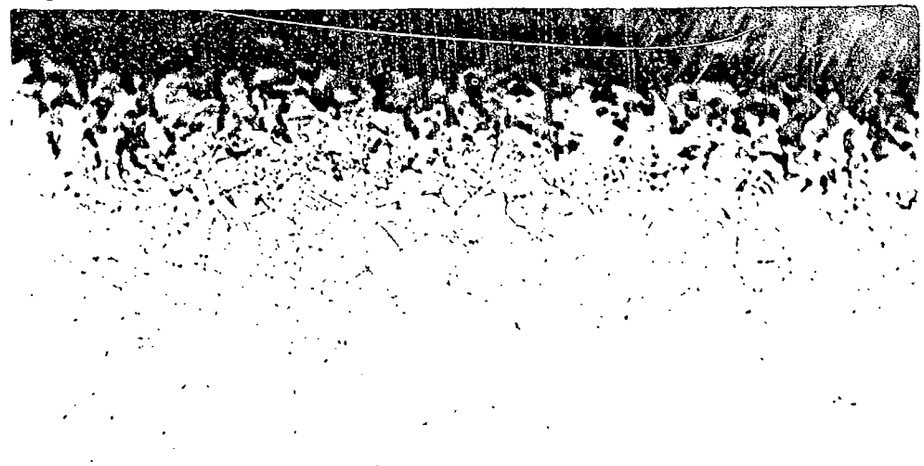
Extreme Corrosive Alloying

M 4421 Lead Sulfide on Hastelloy X Figure 280
Mag: 250X 1800°F Etch: C



Extreme Corrosive Alloying

M 4422 Lead Sulfide on 310 SS Figure 281
Mag: 250X 1800°F Etch: D



Intergranular Corrosion

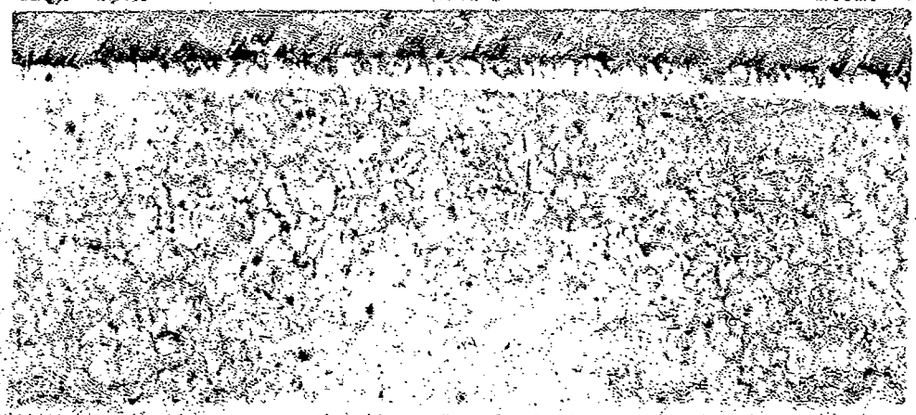
M 4423 Inconel X in Air (Control Specimen) Figure 282
Mag: 250X 1800°F Etch: A

Intergranular Oxidation

M 4424 A-286 in Air(Control Specimen) Figure 283
Mag: 250X 180°F Etch: B

Pitting and Intergranular Oxidation

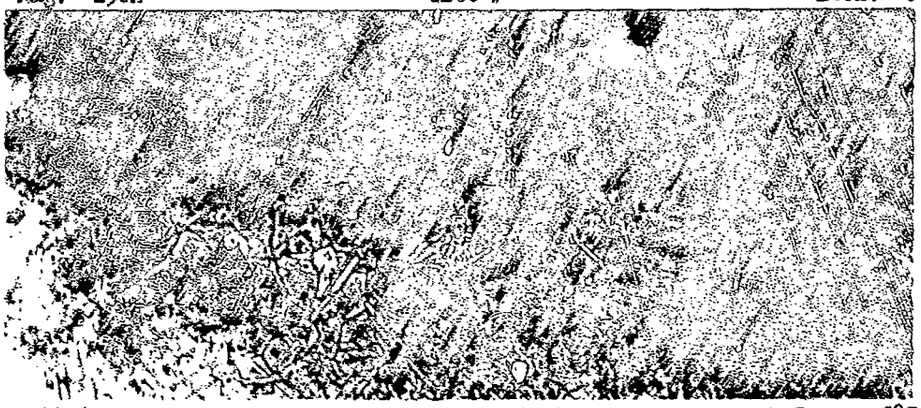
M 4425 René-41 in Air (Control Specimen) Figure 284
Mag: 250X 1800°F Etch: C



Intergranular Oxidation

M 4426 L-605 in Air(Control Specimen) Figure 285
Mag: 250X 1800°F Etch: C

M 4427 Hastelloy X in Air(Control Specimen) Figure 286
Mag: 250X 1800°F Etch: C



M 4428 310 SS in Air (Control Specimen) Figure 287
Mag: 250X 1800°F Etch: D

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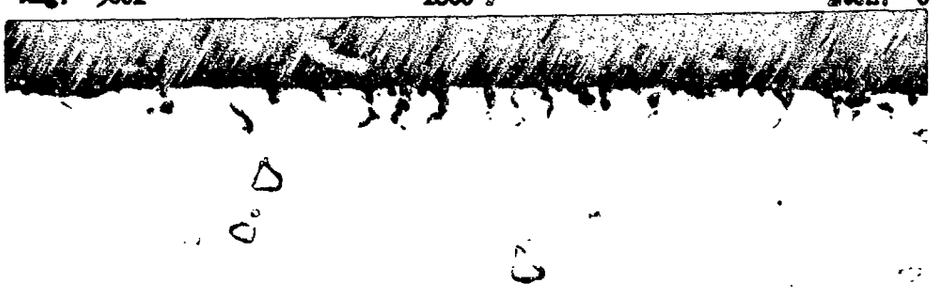
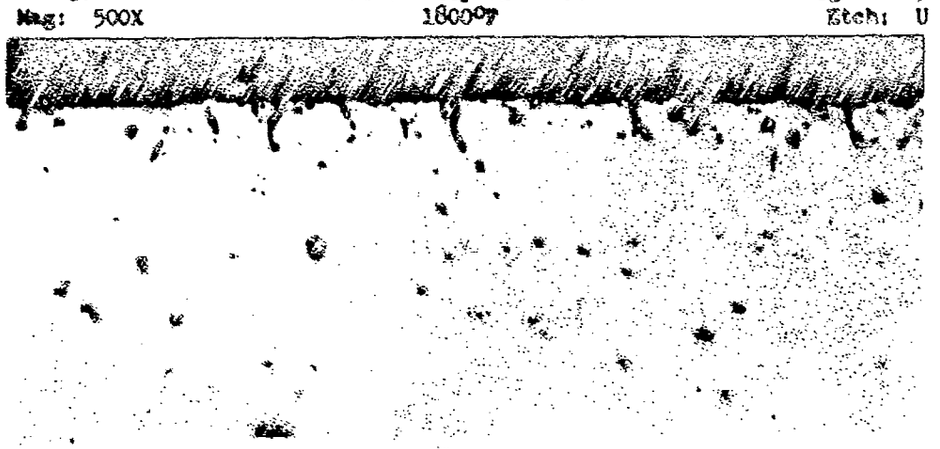
M 4429 Silver Coop on Inconel X Figure 288
Mag: 500X 1800°F Etch: U



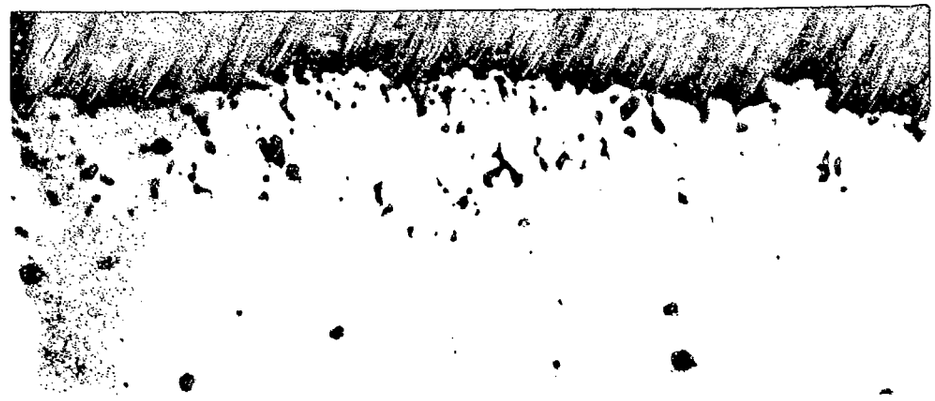
Film and Intergranular Oxidation

M 4430 Silver Coop on A-286 Figure 289
Mag: 500X 1800°F Etch: U



Film and Intergranular Oxidation

M 4431 Silver Coop on René 41 Figure 290
Mag: 500X 18000F Etch: U



Oxidation and Slight Pitting

M 4432 Silver Coop on L-605 Figure 291
Mag: 500X 18000F Etch: U

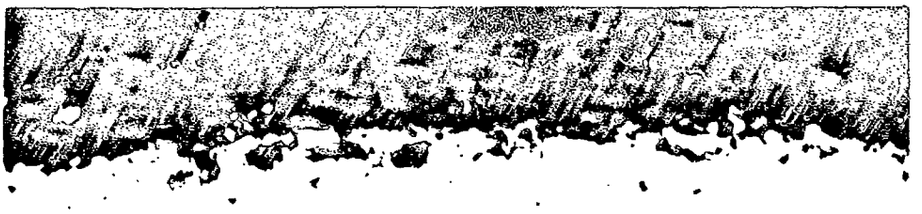
Slight Oxidation

M 4433 Silver Coop on Eastalloy X Figure 292
Mag: 500X 1800°F Etch: U

M 4434 Silver Coop on 310 SS Figure 293
Mag: 500X 1800°F Etch: U

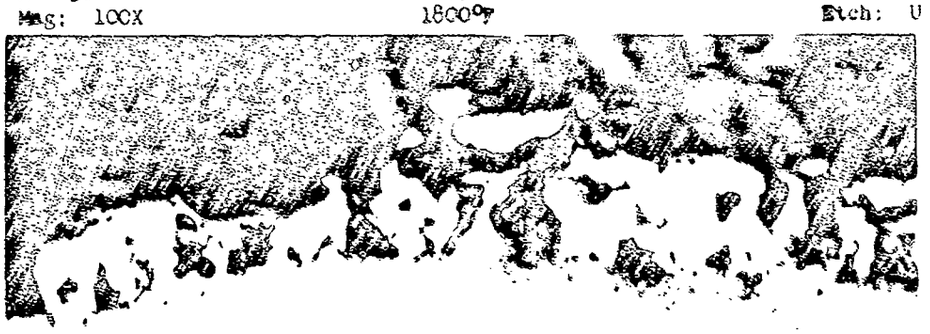
Intergranular Structure

M 4435 Base Off 990 on Inconel X Figure 294
Mag: 100X 1800°F Etch: U



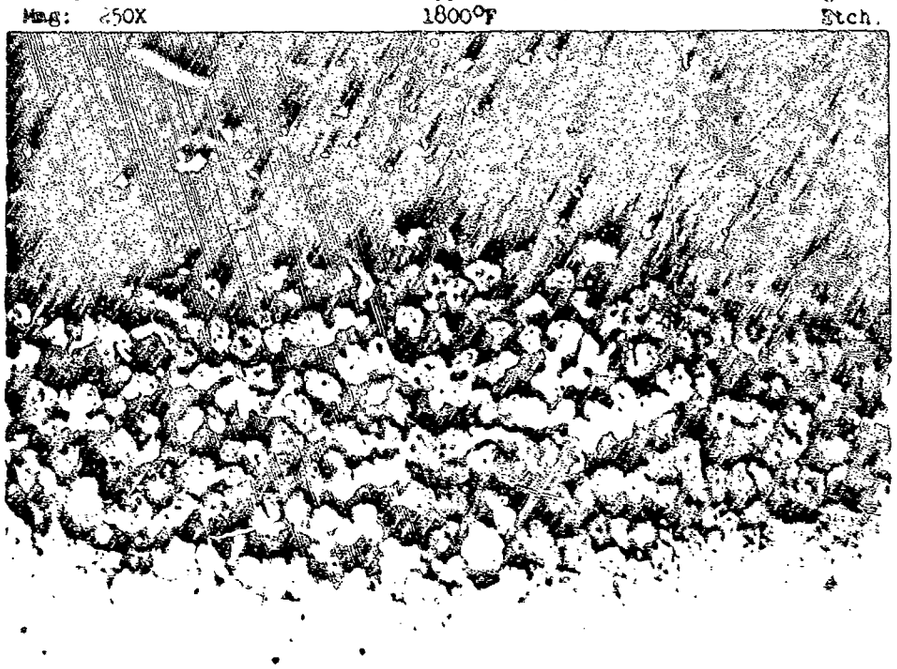
Extreme Oxidation, Pitting, and Corrosive Alloying

M 4436 Base Off 990 on A-286 Figure 295
Mag: 100X 1800°F Etch: U



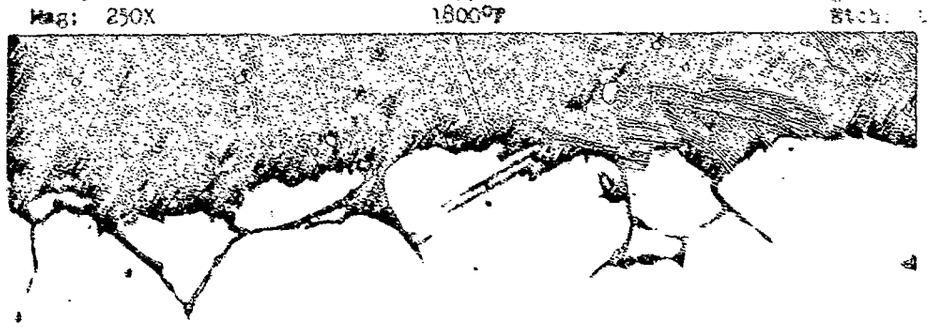
Severe Pitting and Chemical Corrosion

M 4437 Base Off 990 on Rene 41 Figure 29t
Mag: 250X 1800°F Etch. U



Extreme Chemical Corrosion and Corrosive Alloying

M 4438 Base Off 990 on L-605 Figure
Mag: 250X 1800°F Etch.



Intergranular Attack

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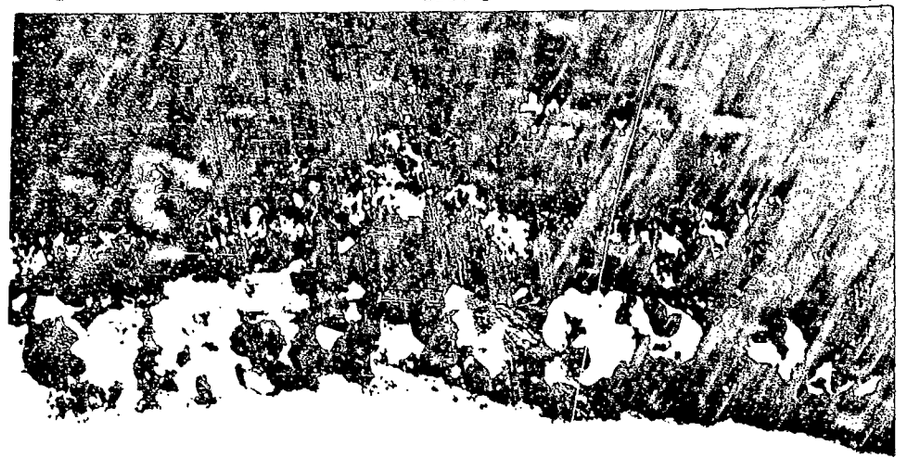
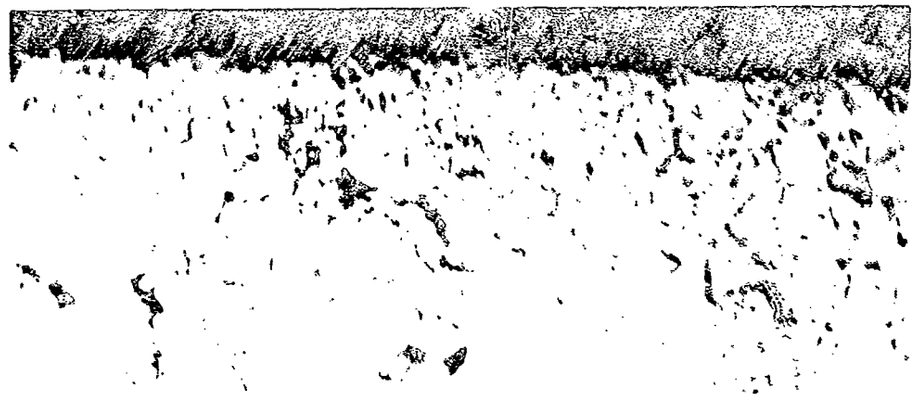
M 4439 Base Off 990 on Hastelloy X Figure 298
Mag: 100X 1800°F Etch: U



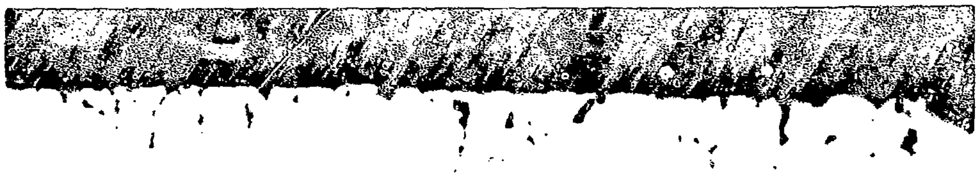
Extreme Pitting and Corrosive Alloying

M 4440 Base Off 990 on 310 SS Figure [illegible]
Mag: 250X 1800°F Etch: [illegible]



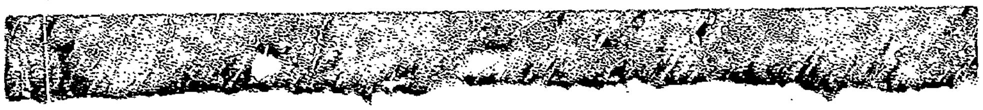
Severe Intergranular Corrosion

M 4441 | Fel. Pro. 65-A on Inconel X | Figure 300
Mag: 500X | 1800°F | Etch: U



Intergranular Oxidation

M [illegible] | Fel. Pro. 65-A on A-286 | Figure [illegible]
Mag. [illegible] | 1800°F | Etch: [illegible]

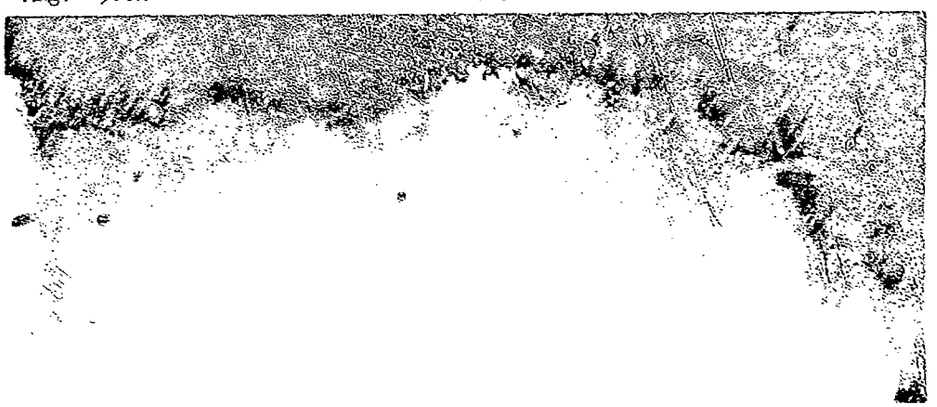


Slight Oxidation

M 4443 Fel. Pro. 65-A on René-41 Figure 302
Mag: 500X 1800°F Etch: U

Oxidation

M 4444 Fel. Pro. 65A on L-605 Figure [illegible]
Mag: 500X 1800°F Etch: U



Oxidation and Slight Pitting

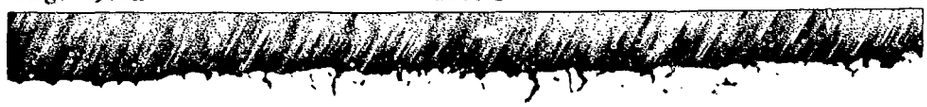
M 4445 Fel. Pro. 65-A on Hastelloy X Figure 304
Mag: 500X 1800°F Etch: U

Slight Oxidation

M 4446 Fel. Pro. 65-A on 310 SS Figure 305
Mag: 500X 1800°F Etch: U

Oxidation and Slight Pitting

M 4447 DGF 123 on Inconel X Figure 306
Mag: 500X 1800°F Etch: U

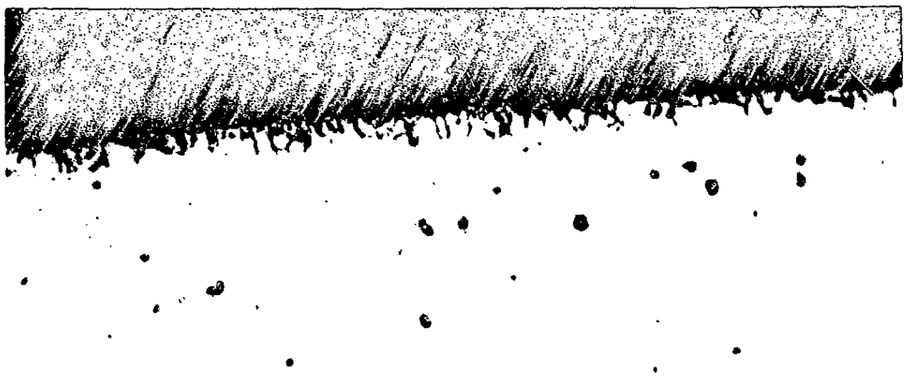


Slight Oxidation

M 4448 DGF 123 on [illegible] Figure 307
Mag: 250X 1800°F Etch: U

Oxidation

M 4449 DCF 123 on Rene'41 Figure 308
Mag: 500X 1800°F Etch: U



Film and Slight Intergranular Oxidation

M 4450 DCF 123 on L-605 Figure 309
Mag: 500X 1800°F Etch: U

Slight Oxidation

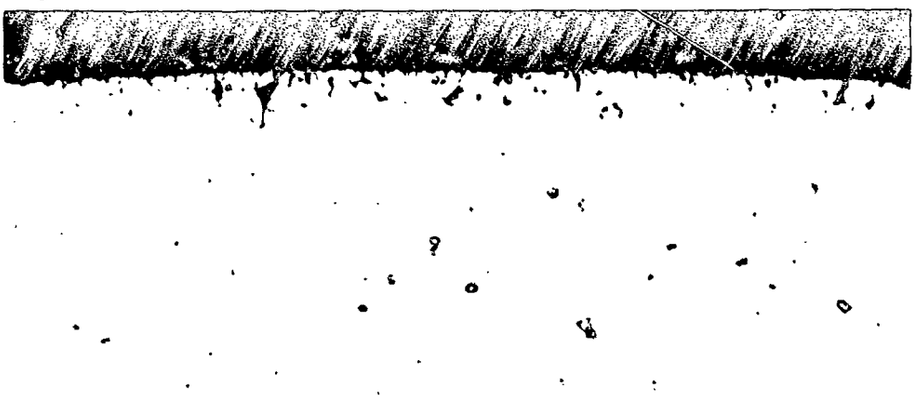
M 4451 DGF 123 on Eastelloy X Figure 310
Mag: 500X 1800°F Etch: U

Film Oxidation and Slight Pitting

M 4452 DGF 123 ox 310 SS Figure 311
Mag: 500X 1800°F Etch: U

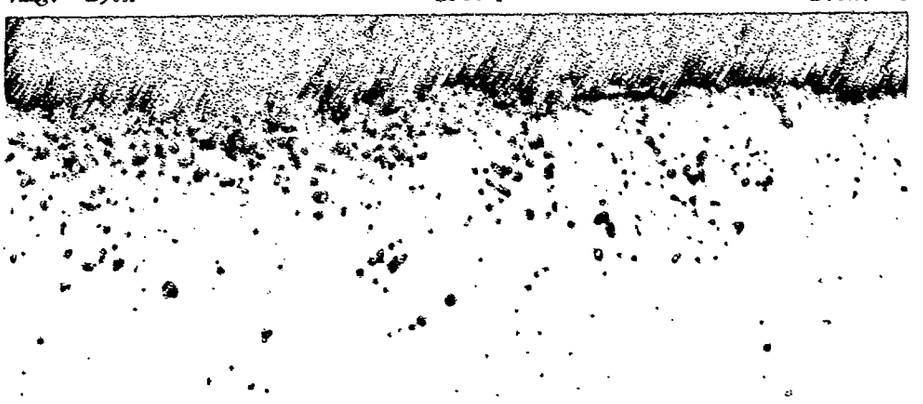
Slight Oxidation

M 4453 MIL-T-5544-A on Inconel X Figure 112
Mag: 500X 1800°F Etch: U



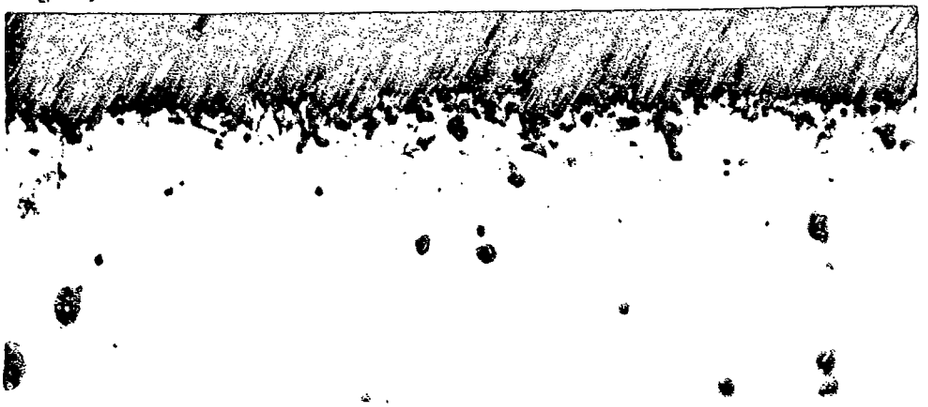
Oxidation and Slight Intergramular Attack

M 4454 MIL-T-5544-A on A-286 Figure 113
Mag: 250X 1800°F Etch: U



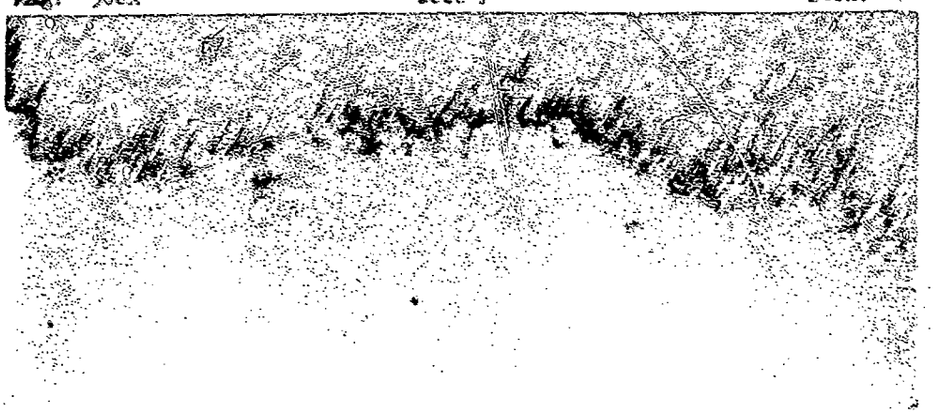
Oxidation and Slight Pitting

M 4455 MIL-T-5544-A on René-41 Figure 314
Mag: 500X 1800°F Etch: U



Oxidation and Pitting

M 4456 MIL-T-5544-A on L-605 Figure 315
Mag: 500X 1800°F Etch: U

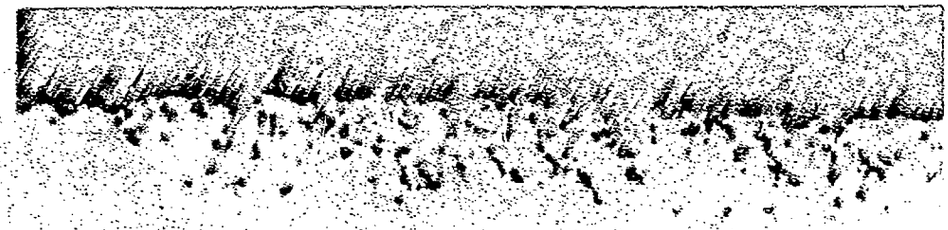


Film Oxidation and Slight Pitting

M 4457 MIL-T-5544-A on Hastelloy X Figure 316
Mag: 500X 1800°F Etch: U

Film Oxidation

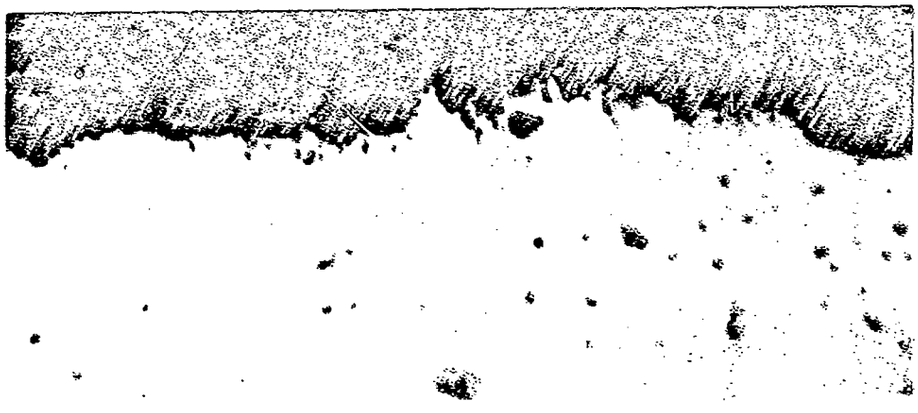
M 4458 MIL-T-5544-A on 310 SS Figure 317
Mag: 250X 1800°F Etch: U



M 4459 Electrofilm 1000 on Inconel X Figure 318
Mag: 500X 1800°F Etch: U

Oxidation and Pitting

M 4460 Electrofilm 1000 on A-286 Figure 319
Mag: 500X 1800°F Etch: U



Pitting

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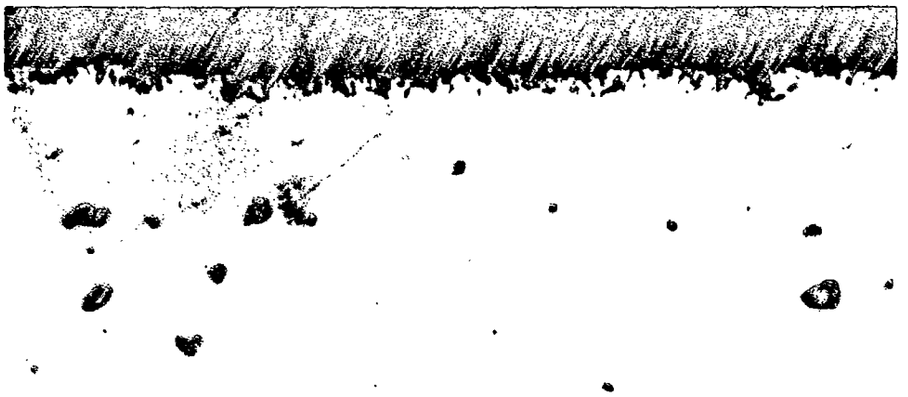
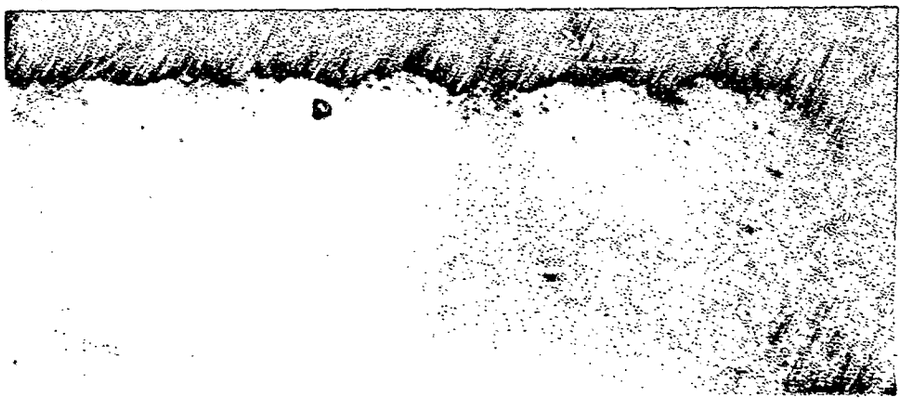
M 4461 Electrofilm 1000 on Rene-41 Figure 320
Mag: 500X 1800°F Etch: U



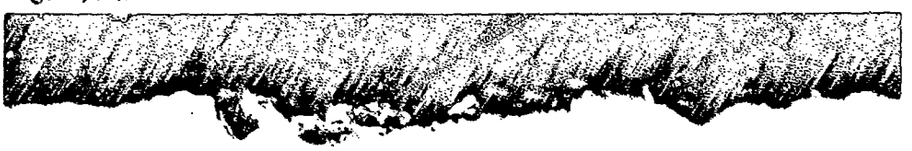
Oxidation and Slight Pitting

M 4462 Electrofilm 1000 on L-605 Figure 321
Mag: 500X 1800°F Etch: U



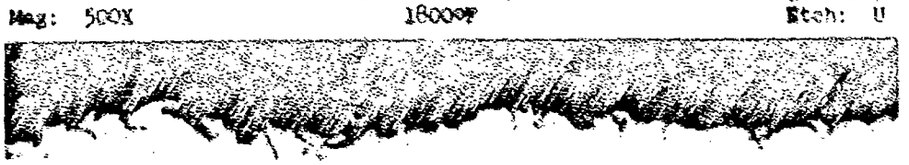
Oxidation and Slight Pitting

M 4463 Electrofilm 1000 on Hastalloy X Figure 322
Mag: 500X 18000F Etch: U



Pitting

M 4464 Electrofilm 1000 on 310 SS Figure 323
Mag: 500X 18000F Etch: U

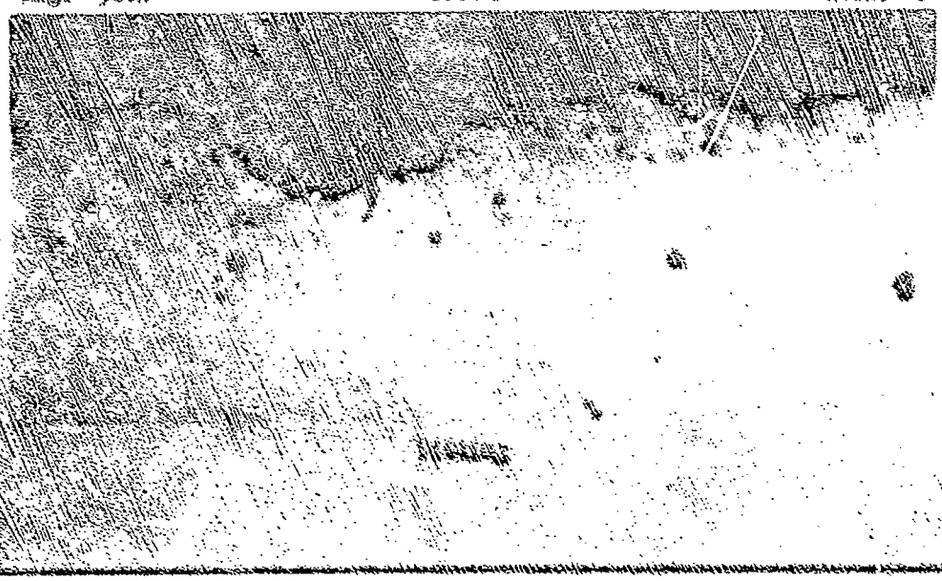


Slight Pitting and Intergranular Attack

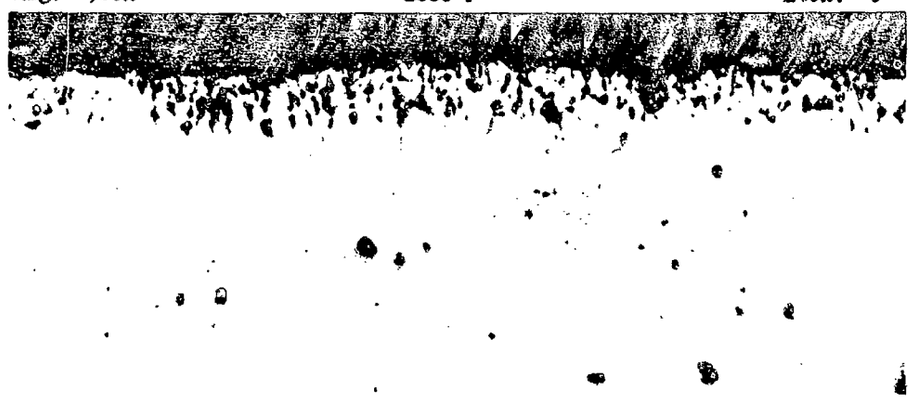
M 4465 Electrofilm 1005 on Inconel X Figure 324
Mag: 500X 180097 Etch: U

Slight Pitting and Intergranular Attack

M 4465 Electrofilm 1005 on [illegible]-286 Figure 325
Mag: 500X 180097 Etch: U

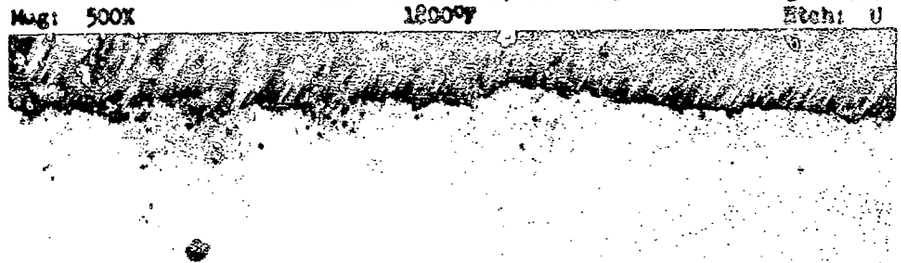


M 4467 Mag: 500X — Electrofilm 1005 on René-41, 1800°F — Figure 326, Etch: U



Oxidation and Slight Pitting

M 4468 Mag: 500X — Electrofilm 1005 on L-605, 1200°F — Figure 327, Etch: U



Slight Oxidation

M 4469 Electrofilm 1005 on Hastelloy X Figure 128
Mag: 500X 1800°F Etch: U

Slight Oxidation

M 4470 Electrofilm 1005 on 310 SS Figure 129
Mag: 500X 1800°F Etch: U

Slight Intergranular Oxidation and Pitting

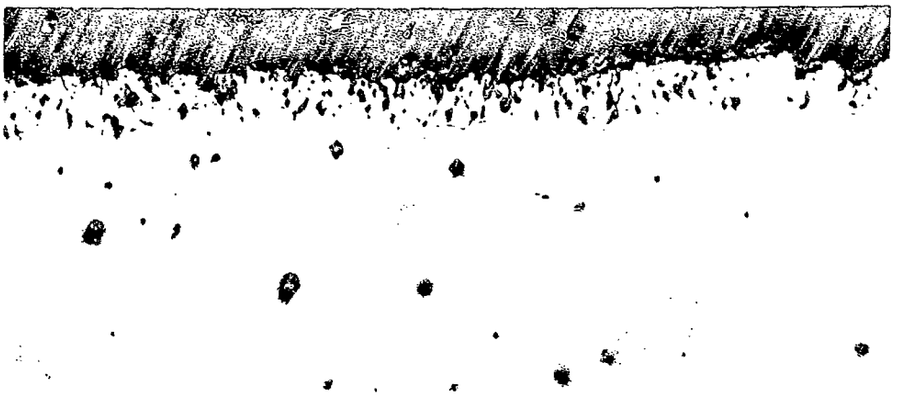
M 4471 Electrofilm 2007 on Inconel X Figure 330
Mag: 500X 1800°F Etch: U

Slight Intergranular Oxidation

M 4472 Electrofilm 2007 on A-286 Figure 331
Mag: 500X 1800°F Etch: U

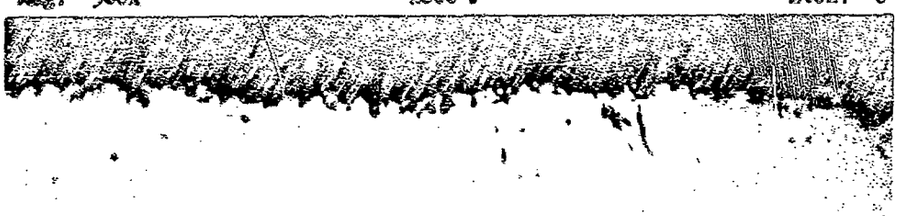
Pitting

M 4473 Electrofilm 2007 on René-41 Figure 332
Mag: 500X 1800°F Etch: U



Oxidation

M 4474 Electrofilm 2007 on L-605 Figure 333
Mag: 500X 1800°F Etch: U



Slight Oxidation and Pitting

M 4475 Electrofilm 2007 on Hastelloy X Figure 334
Mag: 500X 1800°F Etch: U

Pitting

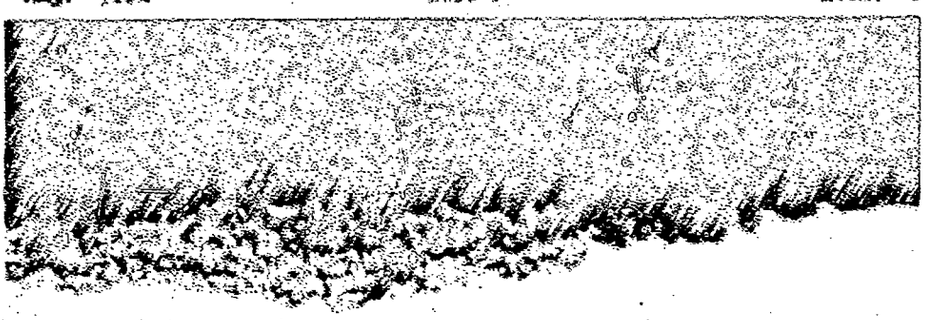
M 4475 Electrofilm 2007 on 310 SS Figure 335
Mag: 500X 1800°F Etch: U

Pitting

M 4477 Electrofilm 66C on Inconel X Figure 336
Mag: 500X 1800°F Etch: U

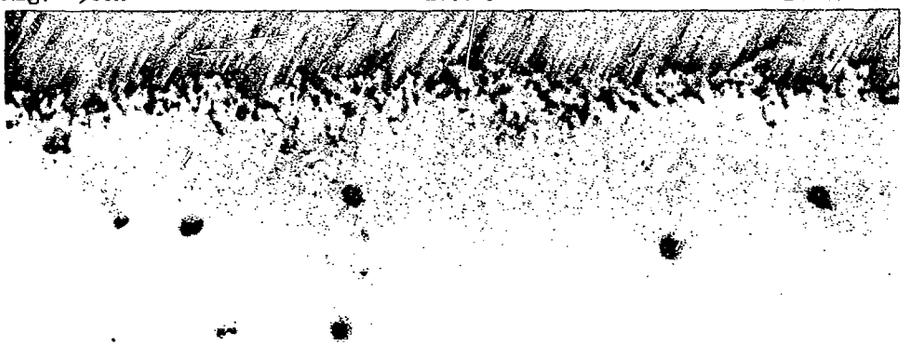
Slight Intergranular Oxidation and Pitting

M 4478 Electrofilm 66C on A-286 Figure 337
Mag: 500X 1800°F Etch: U



Pitting

M 4479 Electrofilm 66C on Rene'-41 Figure 338
Mag: 500X 1800°F Etch: U

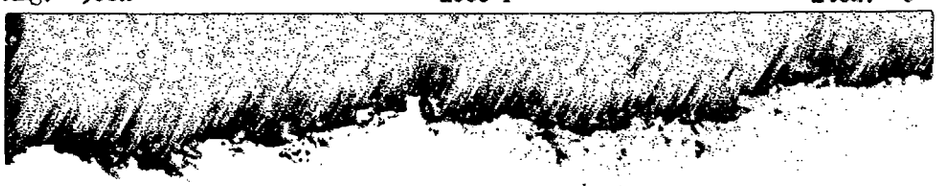


Oxidation

M 4480 Electrofilm 66C on L-605 Figure 339
Mag: 500X 1800°F Etch: U

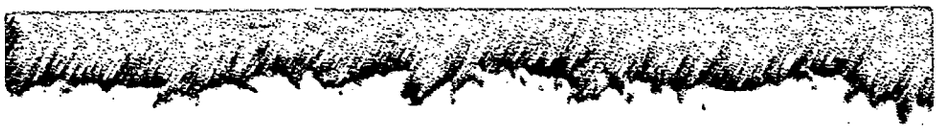
Slight Oxidation and Pitting

M 4481 Electrofilm 66C on Hastelloy X Figure 340
Mag: 500X 1800°F Etch: U



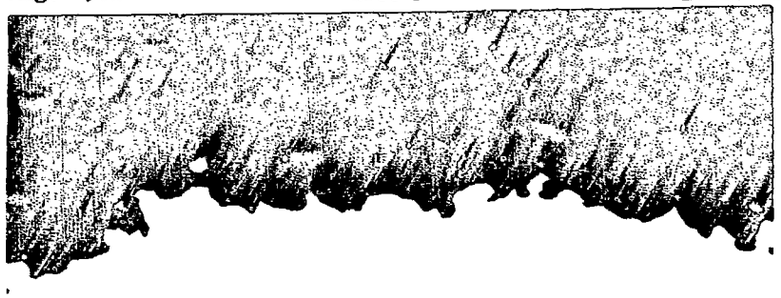
Oxidation and Slight Pitting

M 4482 Electrofilm 66C on 310 SS Figure 341
Mag: 500X 1800°F Etch: U



Slight Oxidation and Pitting

M 4483 Phosphatherm RN on Inconel X Figure 342
Mag: 50X 1800°F Etch: U

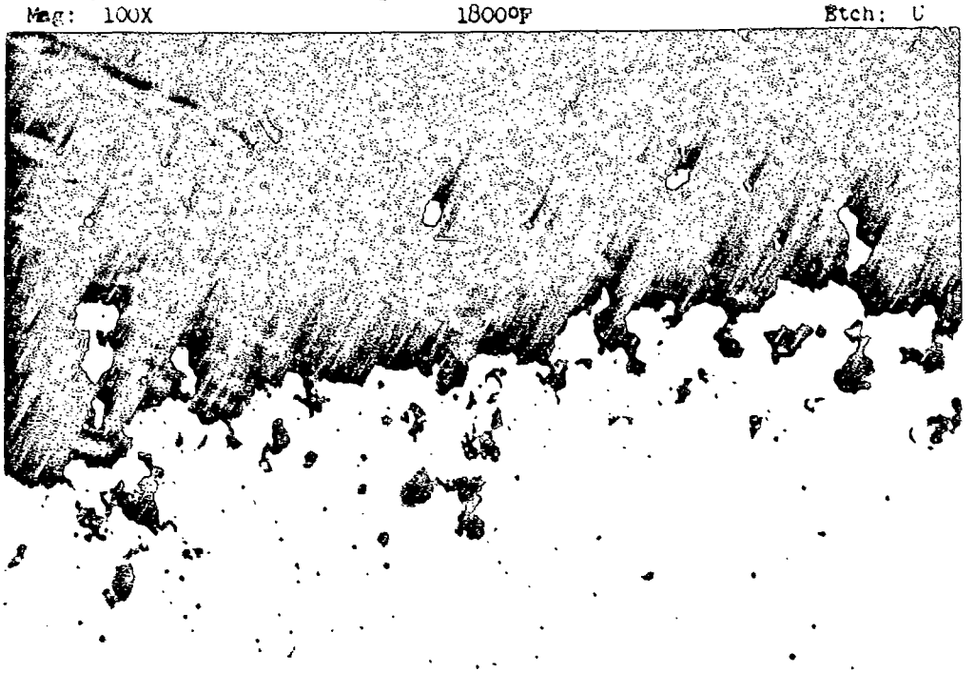


Extreme Pitting and Corrosive Alloying

M 4484 Phosphatherm RN on A-286 Figure 343
Mag: 100X 1800°F Etch: U

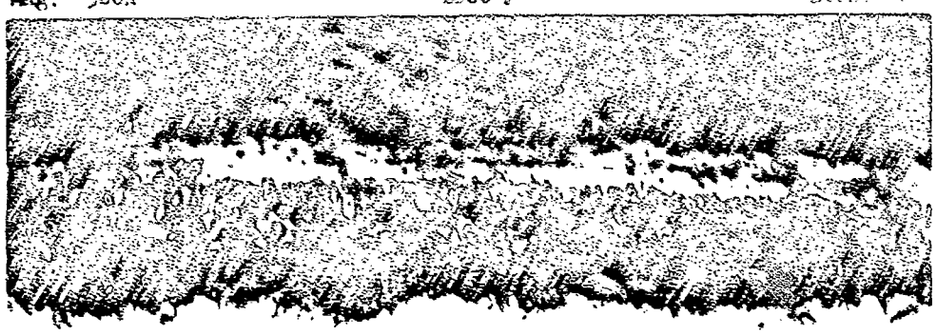
Extreme Corrosive, Alloying and Pitting

M 4485 Phosphatherm RN on René-41 Figure 344
Mag: 100X 1800°F Etch: C



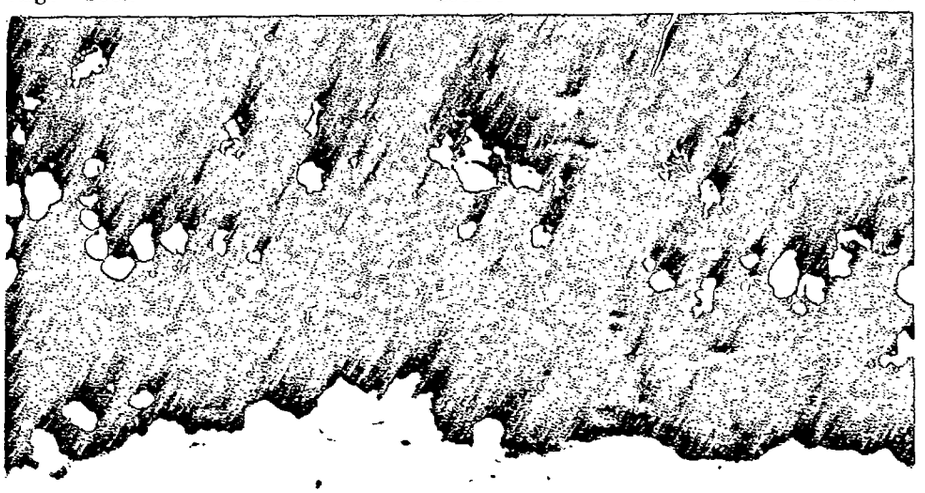
Extreme Chemical Corrosion and Corrosive Alloying

M 4486 Phosphatherm RN on L-605 Figure
Mag: 500X 1800°F Etch:



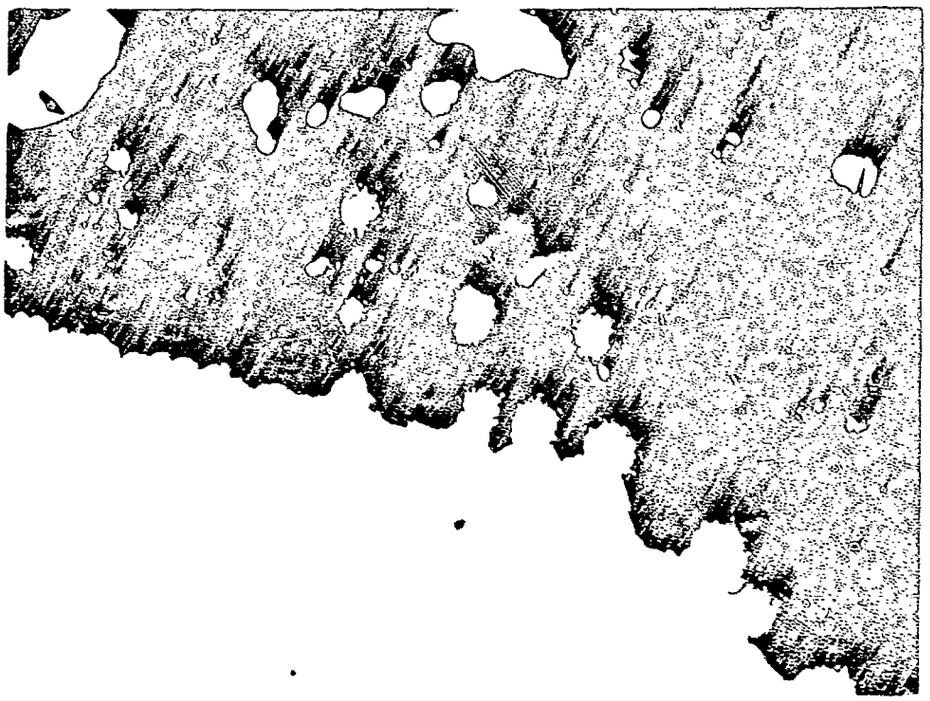
Severe Chemical Corrosion

M 4487 Phosphatherm RN on Hastelloy X Figure 34
Mag: 100X 1800°F Etch: U



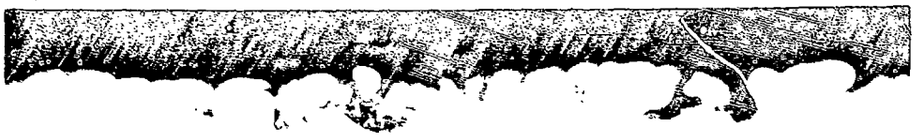
Extreme Chemical Corrosion and Corrosive Alloying

M 4488 Phosphatherm RN on 310 SS Figure 347
Mag: 100X 1800°F Etch: U



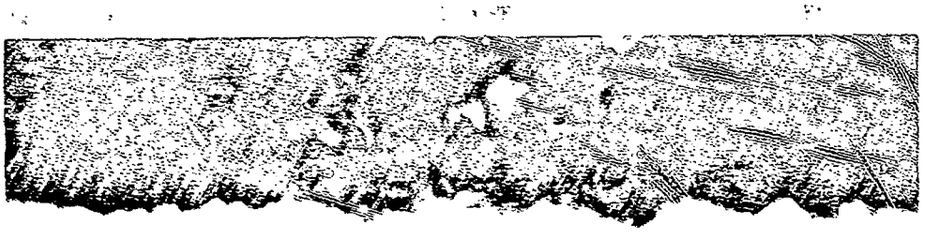
Extreme Pitting and Corrosive Alloying

M[illegible] Sodium Silicate on Inconel X Figure [illegible]
Mag: 50X 1800°F Etch:



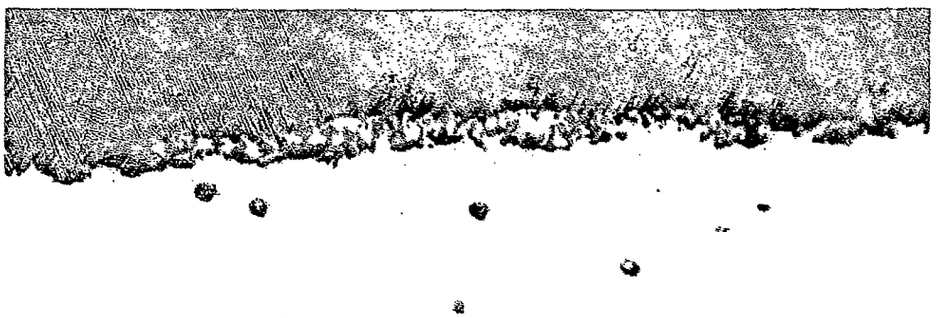
Pitting

S[illegible]



Pitting and Slight Intergranular Attack

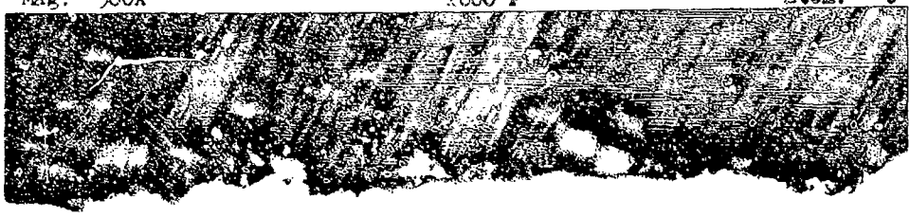
M 4491 Sodium Silicate on René 41 Figure [illegible]
Mag: 500X 1800°F Etch: U



Slight Intergranular Attack

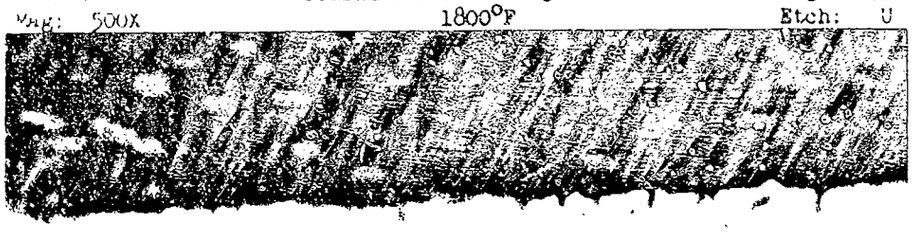
M 4492 Sodium Silicate on L-605 Figure 251
Mag: 500X 1800°F Etch: [illegible]

M 4493 Sodium Silicate on Hastelloy' X Figure 352
Mag: 500X 1800°F Etch: U



Slight Pitting

M 4494 Sodium Silicate on 310 SS Figure 353
Mag: 500X 1800°F Etch: U



Pitting

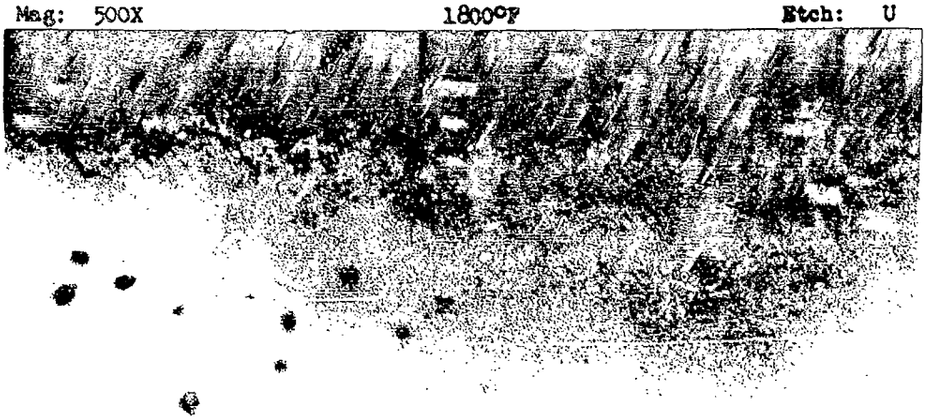
M 4495 Silica on Inconel X Figure 354
Mag: 500X 1800°F Etch: U

Slight Intergranular Oxidation

M 4496 Silica on A-286 Figure 355
Mag: 500X 1800°F Etch: U

Pitting

M 4497 Silica on René 41 Figure 356
Mag: 500X 1800°F Etch: U

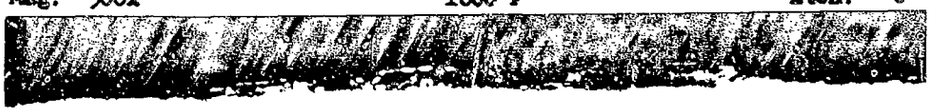


Oxidation Pitting

M 4498 Silica on L-605 Figure 357
Mag: 500X 1800°F Etch: U

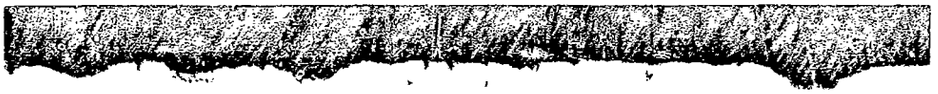
Slight Oxidation

M 4499 | Silica on Hastelloy X | Figure 358
Mag: 500X | 1800°F | Etch: U



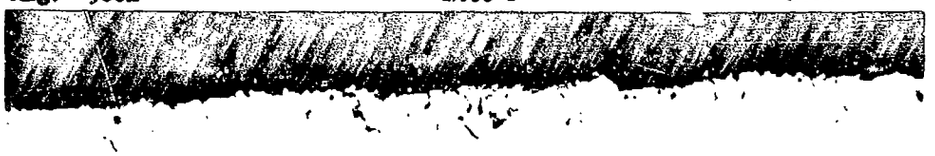
Slight Oxidation

M 4500 | Silica on 310 SS | Figure 359
Mag: 500X | 1800°F | Etch: U



Slight Pitting and Intergranular Attack

M 4501 Milk of Magnesia on Inconel X Figure 360
Mag: 500X 1800°F Etch: U



Film and Intergranular Oxidation

M 4502 Milk of Magnesia on A-286 Figure 361
Mag: 500X 1800°F Etch: U

Pitting

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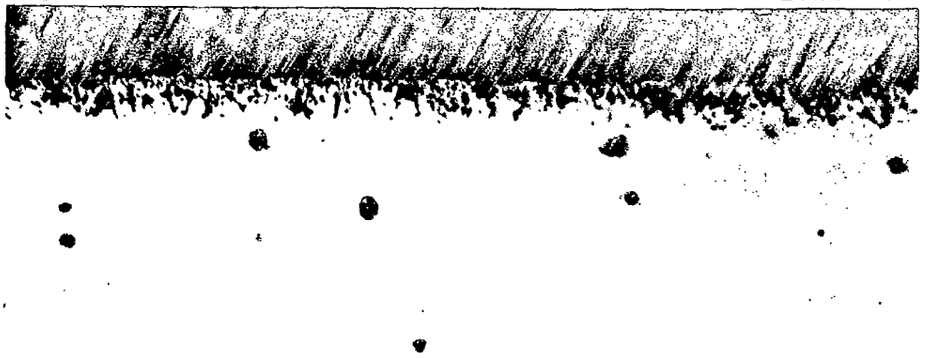
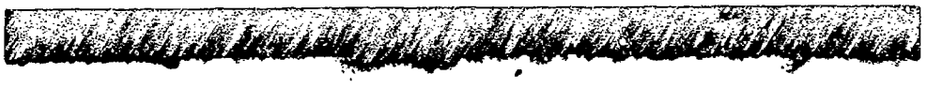
M 4503 Milk of Magnesia on René 41 Figure 362
Mag: 500X 1800°F Etch: U



Oxidation

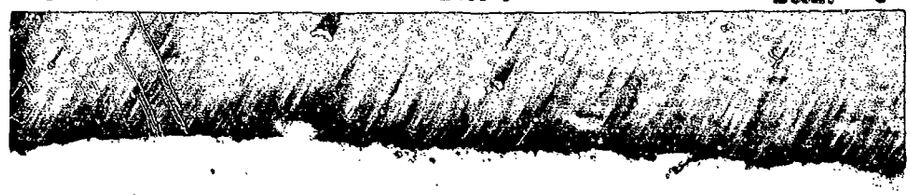
M 4504 Milk of Magnesia on L-605 Figure 363
Mag: 500X 1800°F Etch: U



M 4505
Mag: 500X

Milk of Magnesia on Hastelloy X
1800°F

Figure 364
Etch: U



M 4506
Mag: 500X

Milk of Magnesia on 310 SS
1800°F

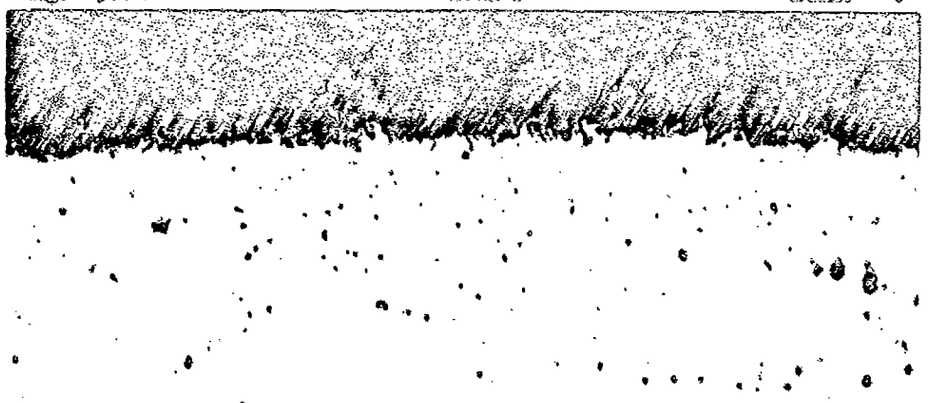
Figure 365
Etch: U

Slight Oxidation and Pitting

M 4507 Magnesium Oxide on Inconel X Figure 366
Mag: 500X 1800°F Etch: U

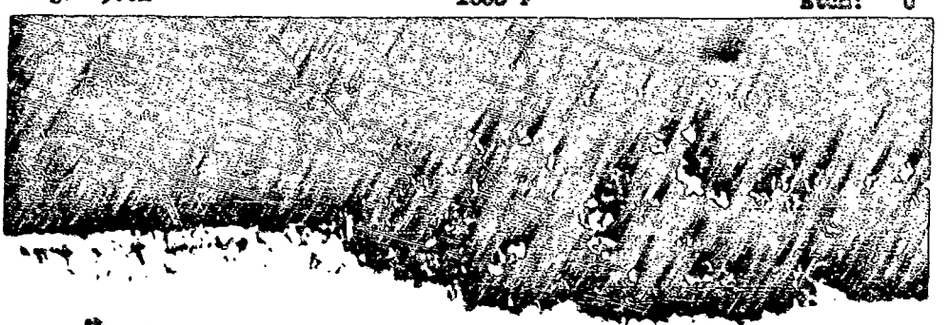
Oxidation and Pitting

M 4508 Magnesium Oxide on A-286 Figure 367
Mag: 500X 1800°F Etch: U



Oxidation

M 4509 Magnesium Oxide on René 41 Figure 368
Mag: 500X 1800°F Etch: U

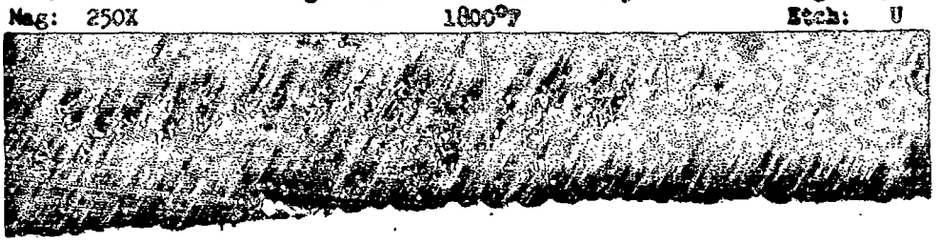


Oxidation and Pitting

M 4510 Magnesium Oxide on L-605 Figure 369
Mag: 250X 1800°F Etch: U

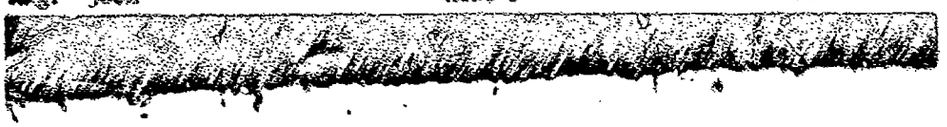
Scale Oxidation

M 4511 Magnesium Oxide on Hastelloy X Figure 370
Mag: 250X 1800°F Etch: U



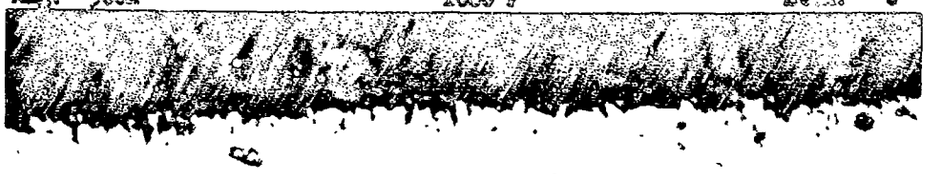
Mild Oxidation

M 4512 Magnesium Oxide on 310 SS Figure 371
Mag: 500X 1800°F Etch: U



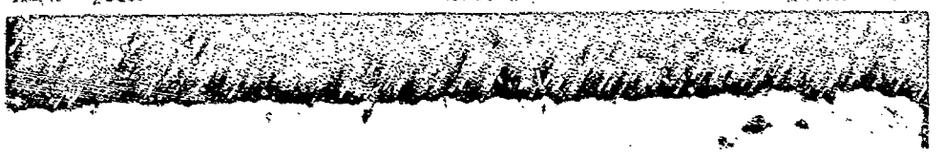
Oxidation and Slight Sintering

M 4513 Boron Nitride On Inconel X Figure 372
Mag: 500X 1800°F Etch: U



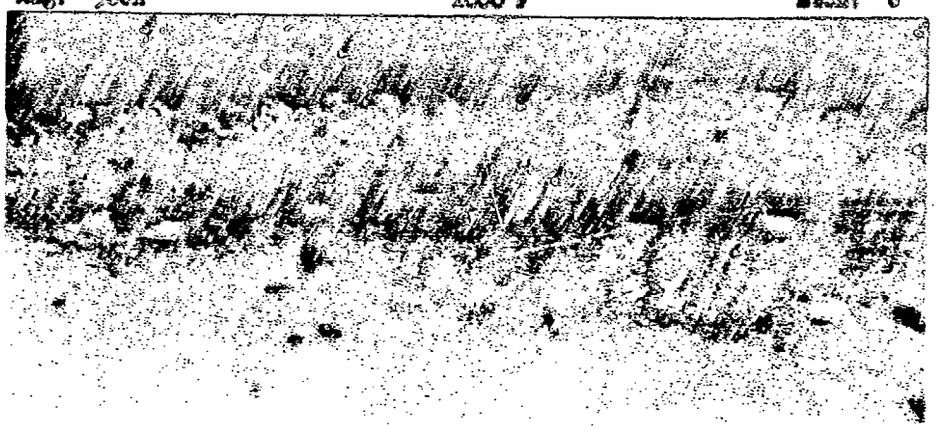
Slight Pitting and Intergranular Oxidation

M 4514 Boron Nitride On A-286 Figure 373
Mag: 500X 1800°F Etch: U



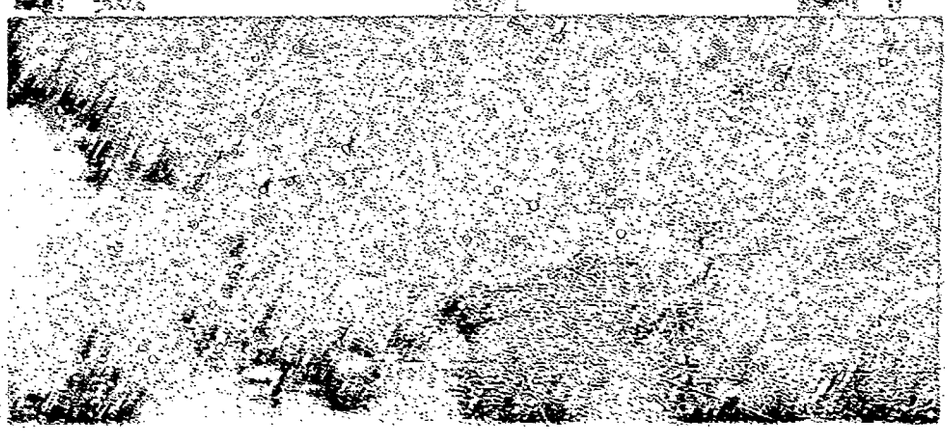
Slight Oxidation and Pitting

M 4515 Boron Nitride on Base #1 Figure 378
Mag: 500X 1600°F Etch: U

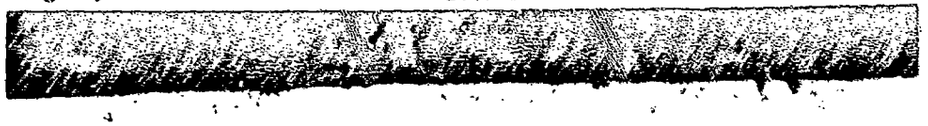


Oxidation

M 4516 Boron Nitride on Lab Figure 379
Mag: 500X Etch: U



M 4517 Boron Nitride on Hastelloy X Figure 376
Mag: 500X 180079 Etch: U

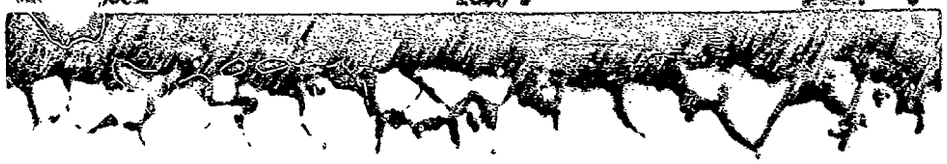


Slight Oxidation

M 4518 Boron Nitride on RD 6B Figure 377
Mag: 500X 180[illegible] Etch: U

Slight Oxidation

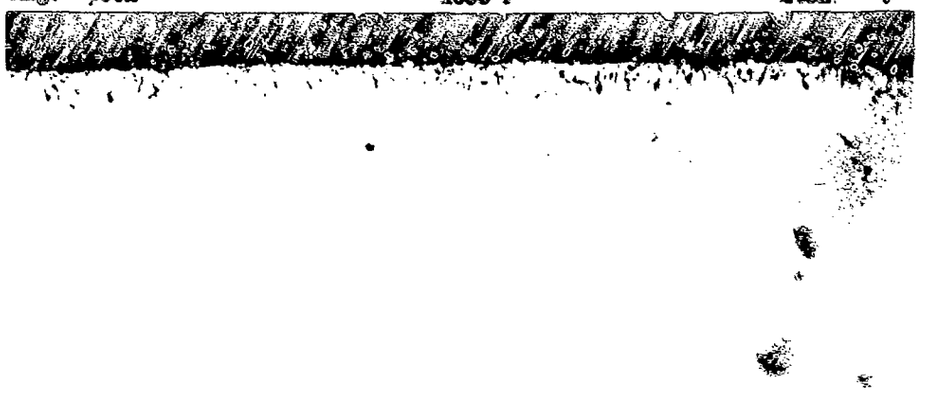
M 4519 Boric Oxide on Inconel X Figure 378
Mag: 500X 1600°F Etch: U



Intergranular Oxidation

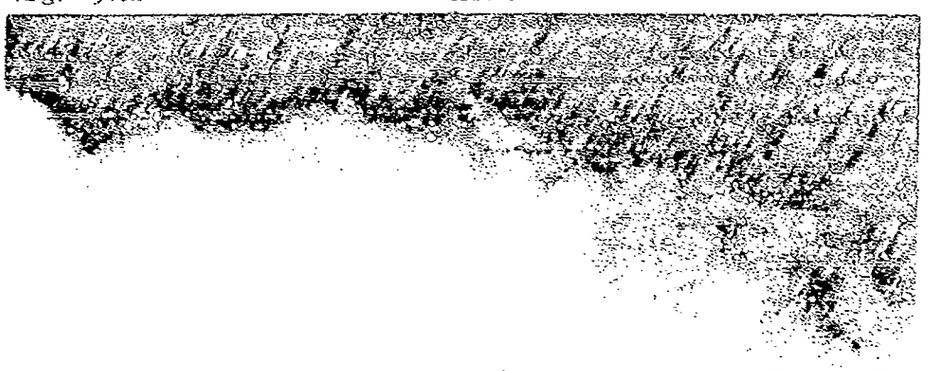
M 4520 Boric Oxide on A-286 Figure 379
Mag: 500X 1500°F Etch: U

M 4521 Boric Oxide on René 41 Figure 380
Mag: 500X 1800°F Etch: U



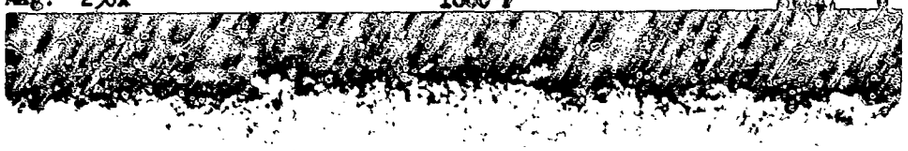
Slight Oxidation

M 4522 Boric Oxide on L-605 Figure 381
Mag: 500X 1800°F Etch: U



Slight Oxidation

M 4523 Boric Oxide on Hastelloy X Figure 382
Mag: 250X 1800°F Etch: II



Intergranular Attack

M 4524 Boric Oxide on 310 SS Figure 383
Mag: 250X 1800°F Etch: II

Intergranular Corrosion

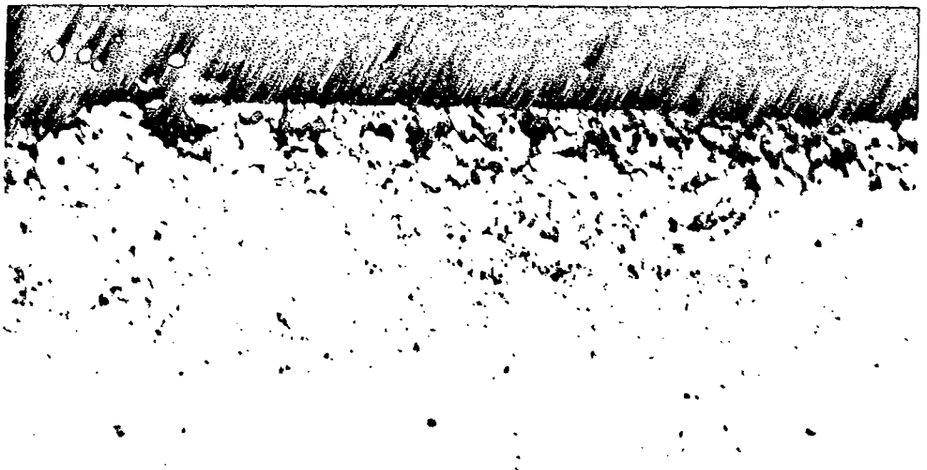
M 4525 Molykote X-106 on Inconel X Figure 384
Mag: 100X 1800°F Etch: U

Intergranular Attack

M 4526 Molykote X-106 on A-286 Figure 385
Mag: 100X 1800°F Etch: U

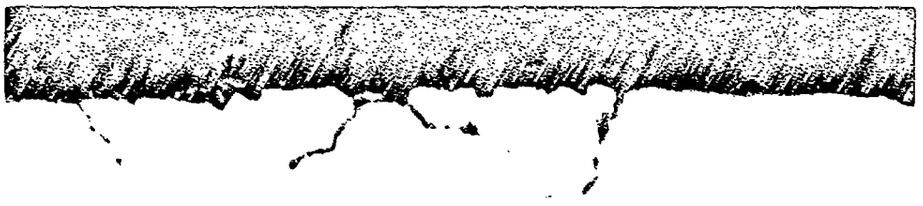
Severe Pitting

M 4527 Molykote X-106 on René 41 Figure 386
Mag: 250X 1800°F Etch: U



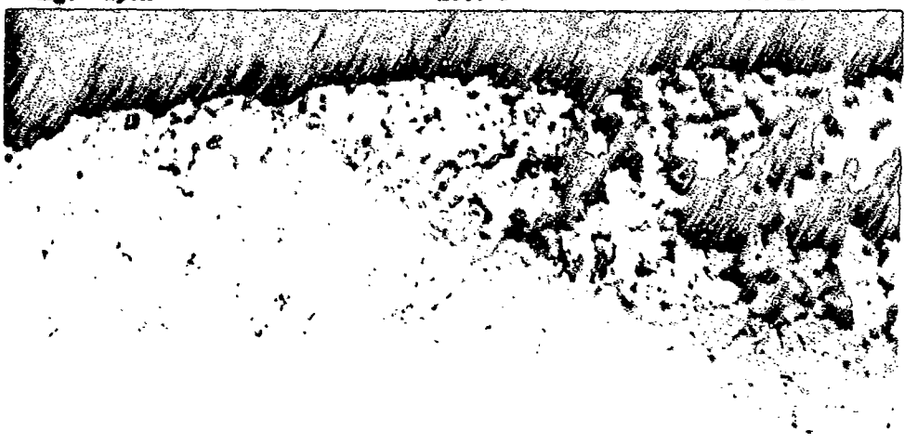
Pitting and Chemical Corrosion

M 4528 Molykote X-106 on L-605 Figure 387
Mag: 250X 1800°F Etch: U



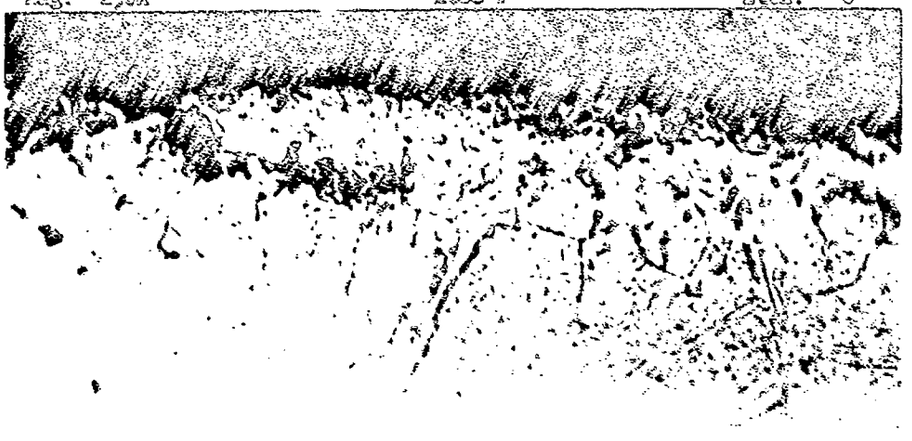
Intergranular Attack

M 4529 Kolykote X-106 on Hastelloy X Figure 388
Mag: 250X 1800°F Etch: U



Intergranular Attack and Corrosive Alloying

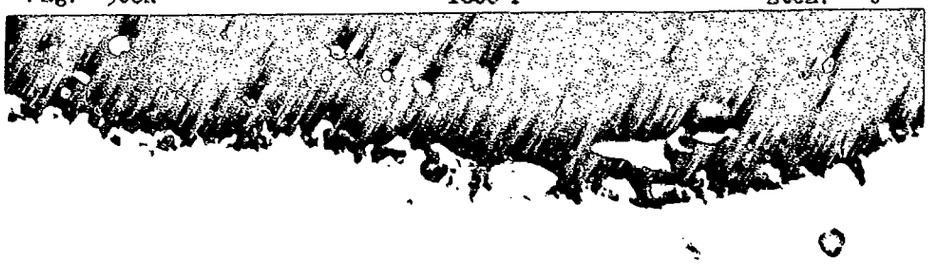
M 4530 Kolykote X-106 on 310 SS Figure 389
Mag: 250X 1800°F Etch: U



Intergranular Corrosion

M 4531 Lead Monoxide on Inconel X Figure 390

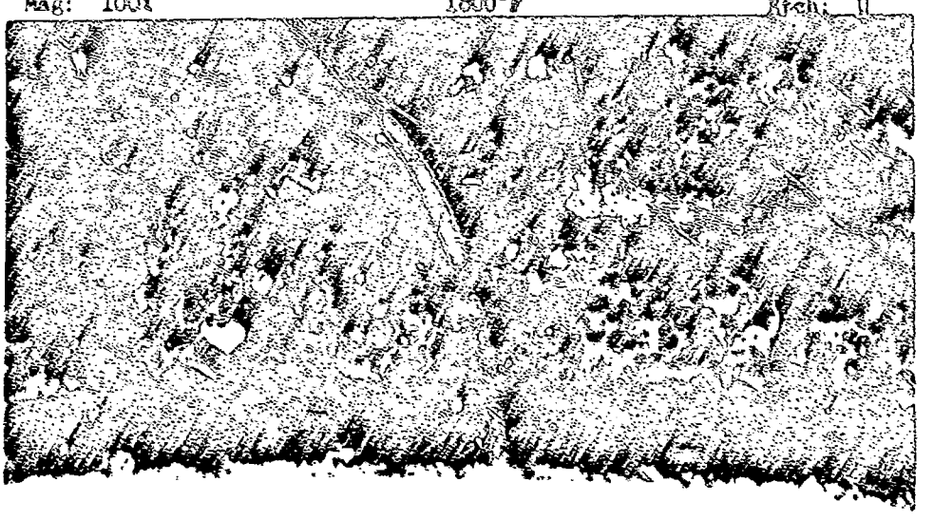
Mag: 500X 1800°F Etch: U



Chemical Corrosion and Pitting

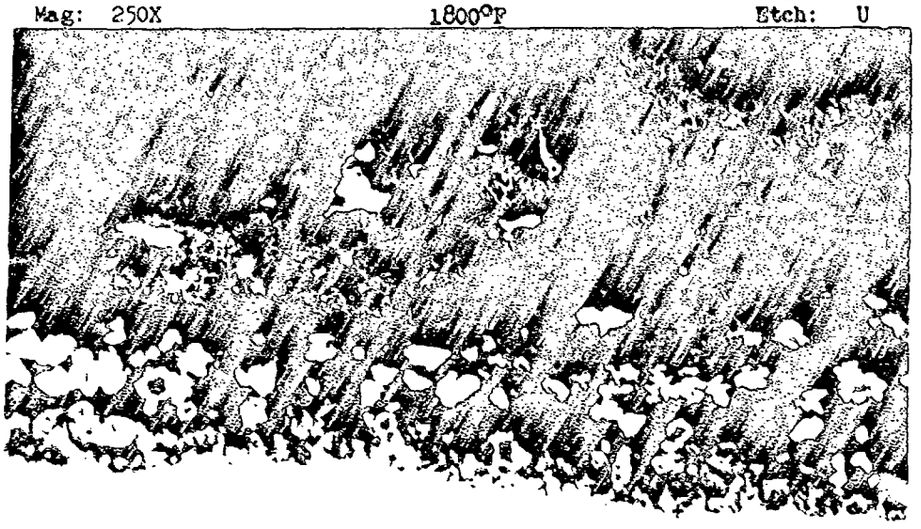
M 4532 Lead Monoxide on A-286 Figure 391

Mag: 100X 1800°F Etch: U



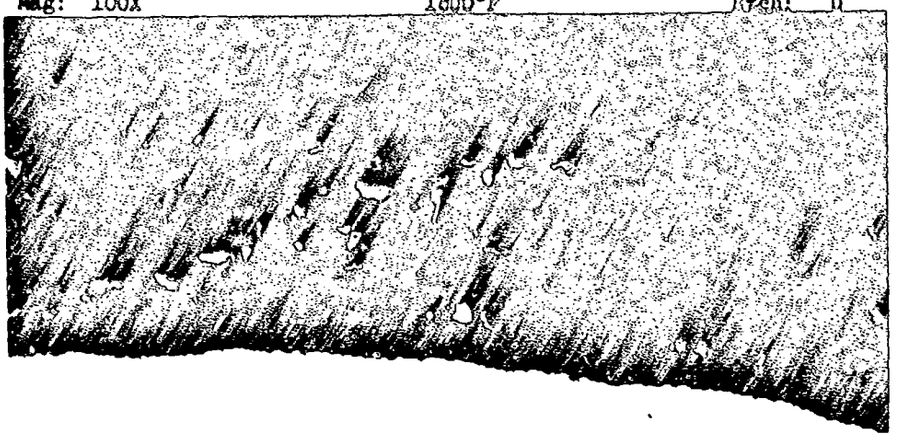
Oxidation and Pitting

M 4533 Lead Monoxide on René 41 Figure 392
Mag: 250X 1800°F Etch: U



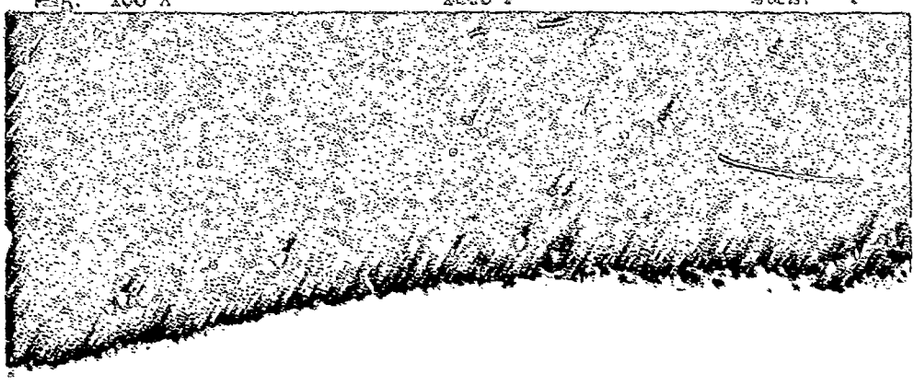
Chemical Corrosion

M 4534 Lead Monoxide on L-605 Figure 393
Mag: 100X 1800°F Etch: U



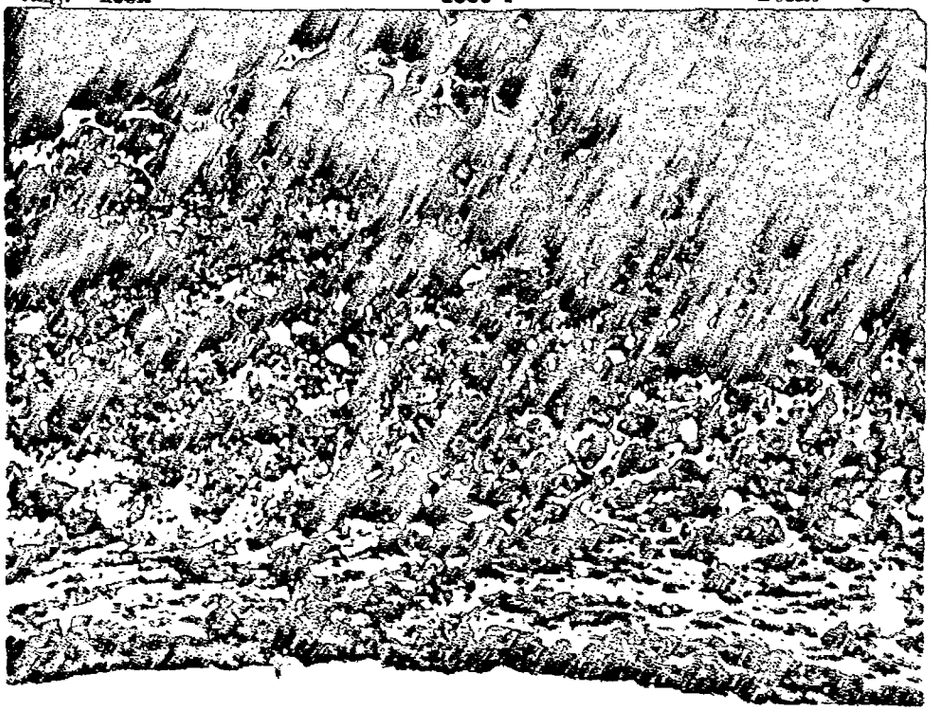
Scale Oxidation

M 4535 Lead Monoxide on Hastelloy X Figure 394
Mag: 100 X 1800°F Etch: U



Oxidation

M 4536 Lead Monoxide on 310 SS Figure 395
Mag: 100X 1800°F Etch: U

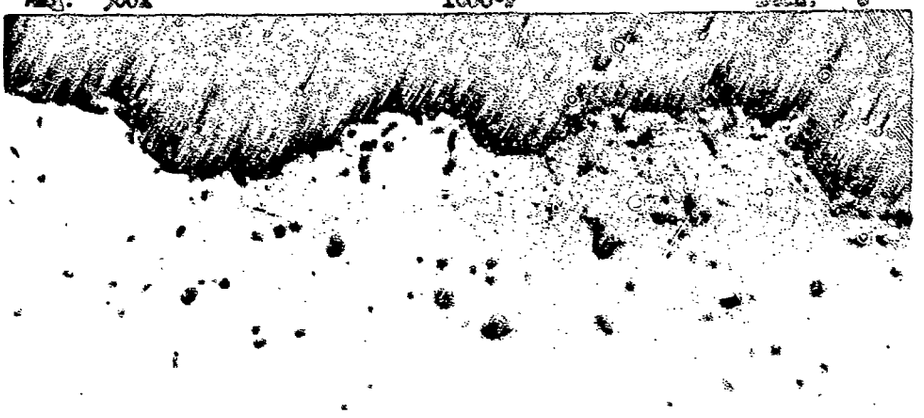


Oxidation

M 4537 Calcium Fluoride on Inconel X Figure 396
Mag: 500X 1800°F Etch: U

Oxidation and Pitting

N 4538 Calcium Fluoride on A-286 Figure 397
Mag: 500X 1000X Etch: U



Pitting

N 4539 Calcium Fluoride on Rene 41 Figure 398
Mag: 500X 1000X Etch: U

Oxidation

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M 4540 Calcium Fluoride on L-605 Figure 399

Mag: 500X [illegible] Scale: 0

Oxidation

M 4541 Calcium Fluoride on [illegible] Figure 400

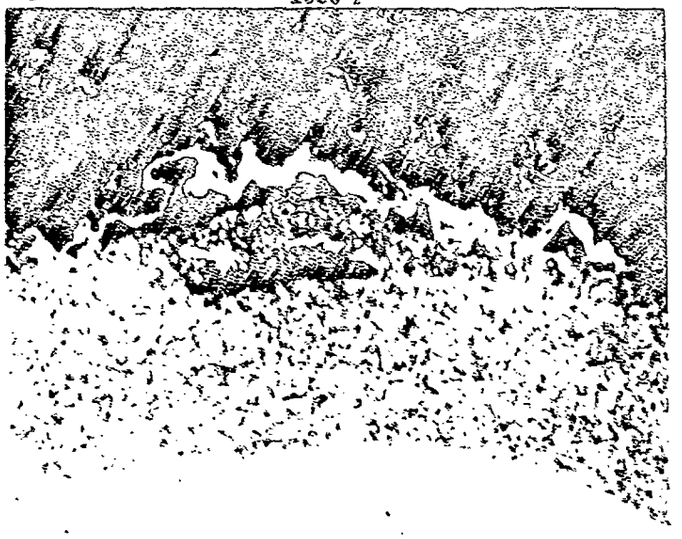
Mag: 500X 1000Å Scale: 0

Oxidation and Grain Pitting

M 4542 Calcium Fluoride on 310 SS Figure 401
Mag: 500X 1800°F Etch: U

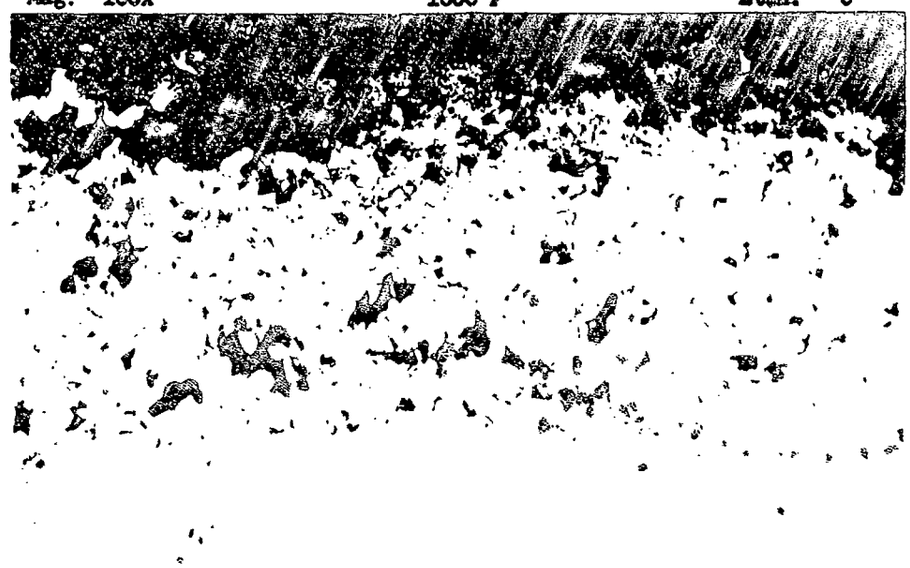
Slight Pitting and Intergranular Oxidation

M 4543 Lead Sulfide on Inconel X Figure 402
Mag: 50X 1800°F Etch: U



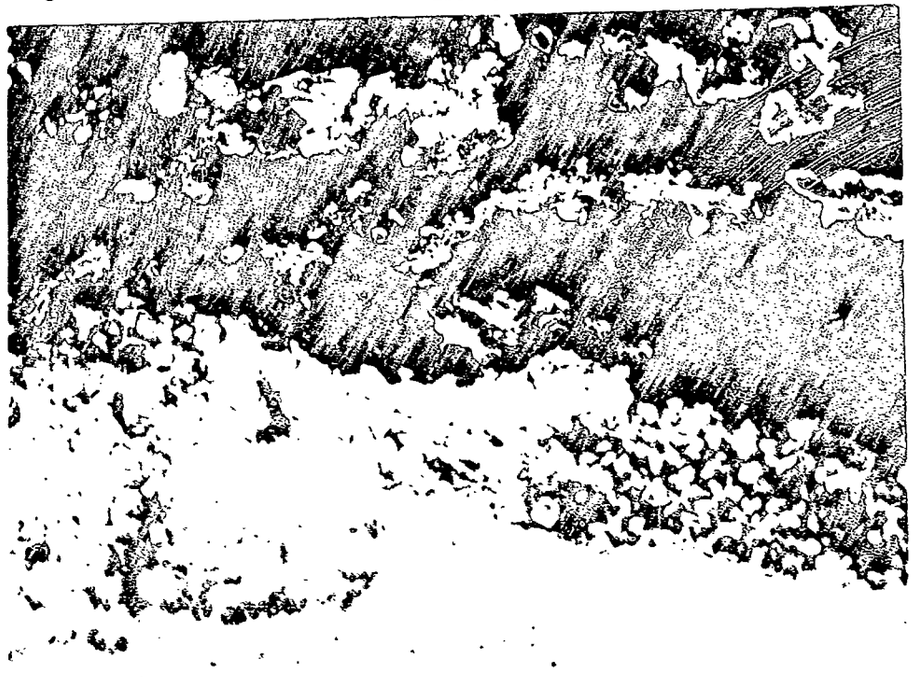
Extreme Corrosive Alloying

M 4544 Lead Sulfide on A-286 Figure 403
Mag: 100X 1800°F Etch: U



Extreme Corrosive Alloying

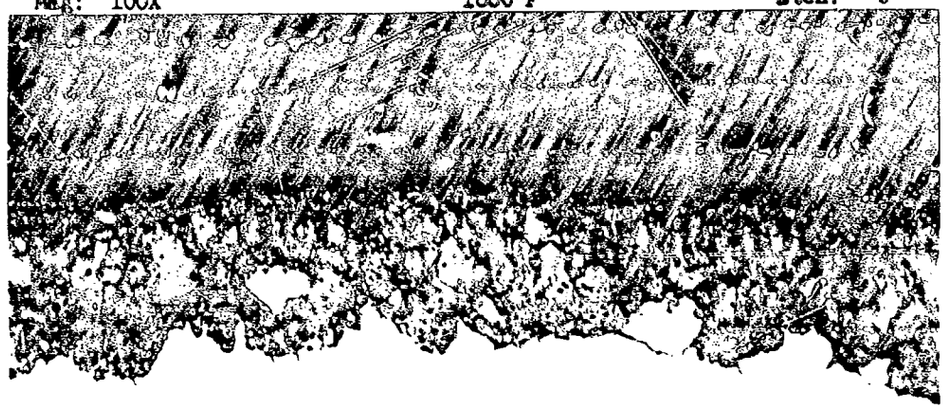
M 4545 Lead Sulfide on René-41 Figure 404
Mag: 100X 1800°F Etch: U



Extreme Corrosive Alloying

M 4546 Lead Sulfide on L-605 Figure 405

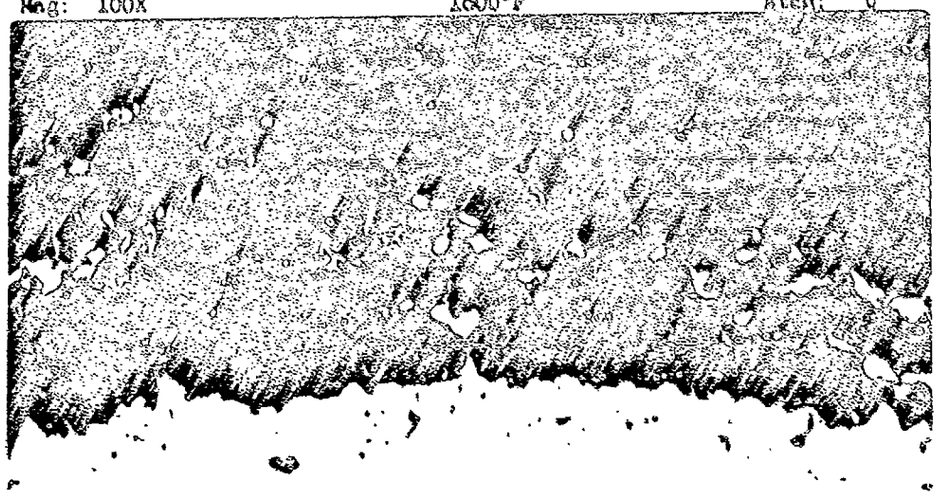
Mag: 100X 1800°F Etch: U



Extreme Corrosive Alloying

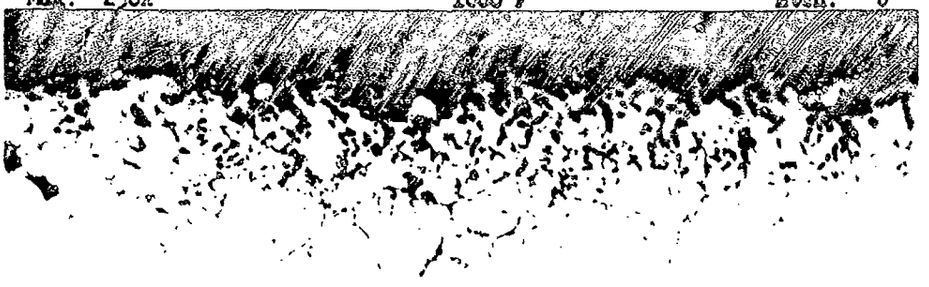
M 4547 Lead Sulfide on Hastelloy X Figure 406

Mag: 100X 1800°F Etch: U



Extreme Corrosive Alloying

M 4548 Lead Sulfide on 310 SS Figure 407
Mag: 250X 1800°F Etch: U

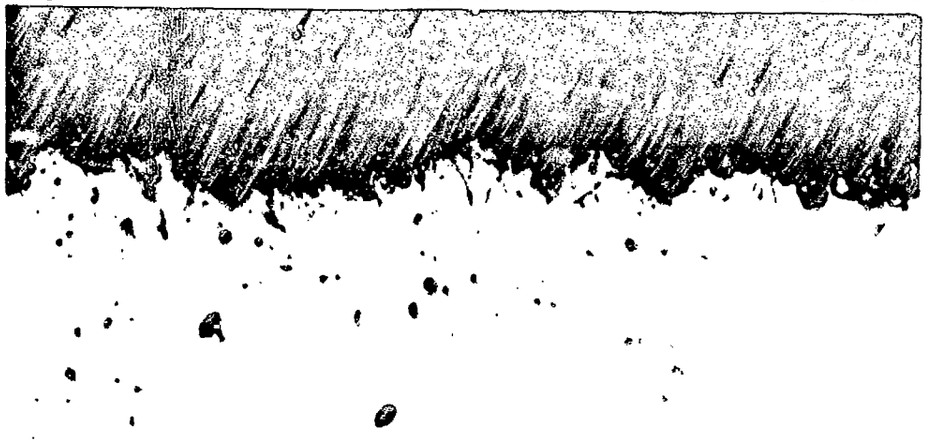


Intergranular Corrosion

M 4549 Inconel X in Air (Control Figure 408
Mag: 500X 1800°F Specimen) Etch: U

Intergranular Oxidation

M 4550 A-286 in Air (Control Specimen) Figure 409
Mag: 500X 1800°F Etch: U



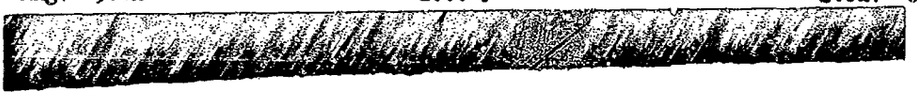
Pitting

M 4551 René-41 in Air(Control Specimen) Figure 410
Mag: 500X 1800°F Etch: U

Film and Intergranular Oxidation

M 4552 — L-605 in Air (Control Specimen) — Figure 411
Mag: 500X — 1800°F — Etch: U

M 4553 — Hastelloy X in Air (Control Specimen) — Figure 412
Mag: 500X — 1800°F — Etch: U



M 4554 — 310 SS in Air (Control Specimen) — Figure 413
Mag: 500X — 1800°F — Etch: U

Oxidation

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INDEX OF PHOTOMICROGRAPHS OF 1800F EXPOSURE SPECIMENS (UNETCHED) (CONT'D.)

DATE_____

REVISED_____

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INDEX OF PHOTOMICROGRAPHS OF 1800F EXPOSURE SPECIMENS (UNETCHED)(CONT'D.)

NAC 1068 (REV. 26 JAN. 59)
PAGE 1 OF 4

TEST REQUEST

TITLE THE EFFECT OF ANTISEIZING COMPOUNDS AND LUBRICANTS ON HIGH TEMPERATURE ALLOYS AT ELEVATED TEMPERATURE

LABORATORY OR DEPT. RESPONSIBLE FOR TEST	MODEL
Department 655, Materials Lab.	Misc.
TEST PARTS ON IBM ☐; ON TPL NO. ____ PRODUCTION PARTS FOR TEST NOT REQUIRED ☒	APL/EPL None

WORK REQUESTED

OBJECTIVE (GIVE PURPOSE OF TEST, WORK AND DATA REQUIRED INCLUDING SERVICE HISTORY AND BACKGROUND INFORMATION)

(B) 1. OBJECT: Rev. B Revised pages 1, 2 and 3 to correct callouts and substitute compounds. No add'l MH required

To determine the metallurgical effect that antiseizing compounds have on super alloys at elevated temperature.

2. HISTORY:

The uses of antiseizing compounds on super alloys, particularly at elevated temperatures, may result in serious consequences. Very little information is available concerning the metallurgical effects when using these compounds.

Work on this T.R. will be done in two phases. The first phase is checking for metallurgical effects on the alloys per the basic T.R. Later, an addendum will be added to check the effect of these compounds in threaded connections.

3. MATERIALS:

	ALLOY	SPEC.	SIZE
3.1			
3.1.1	Inconel X	AMS 5667	1/4" to 1/2" dia.
3.1.2	A-286	AMS 5735	X 6.0'*
3.1.3	Rene' 41	Commercial	
3.1.4	L-605	AMS 5759	
3.1.5	Hastalloy X	AMS 5753 (6)	
3.1.6	310 Stainless Steel	AMS 5651	
3.1.7	4130 Steel	MIL-S-6758 Cond. C	Same dia., but 3 ft. long

*Depends on availability. All specs. should be same diameter.

3.2 Compounds

3.2.1 Silver Goop-Jackson Supply Co., St. Louis, Mo.

REFERENCES OR ENCLOSURES
*IDEP SUMMARY RPT REQUESTED.
Rev "A" Approved: R Beckmann/E M. Pegan
3-17-61

3.2.2 Crane #425A - Crane Plumbing Supply Co., St. Louis

3.2.3 Easy Off #990 - Texaco Co.

3.2.4 Fel-PRO-C-5 - Available at M.A.C.

3.2.5 DGZ 123 - Miracle Power Products, Cleveland, Ohio

(6) ~~3.2.6 Motor Mica Paste - Imbricoal Corp. - D. 684~~

3.2.7 MIL-T-5544A - Available at M.A.C.

3.2.8 Electrofilm 1000 - Dynacraft Corp., St. Louis

3.2.9 Electrofilm 1005 - " " "

3.2.10 Electrofilm 2006 - " " "

3.2.11 Electrofilm 66C - " " "

(6) 3.2.12 Phosphatherm R", Alpha Molykote Corp., Stamford, Conn.

3.2.13 Molykote X-106M - Available in D. 655 - Test only at 1000°F (5)

3.2.14 Sodium Silicate (powder) - Available in D. 655

3.2.15 Silica ~~(in solution with acetone)~~ - Available in D. 655

3.2.16 Milk of Magnesia - Available in D. 655

3.2.17 Magnesium Oxide (fine powder) - Available in D. 655

3.2.18 Boron Nitride - Available in D. 655

3.2.19 Boric Oxide - Available in D. 655

(4) 3.2.20 ~~Molykote~~ I-106 [illegible] - Available in D. 655

3.2.21 Lead Monoxide - Available in D. 655

3.2.22 Calcium Fluoride - Available in D. 655

3.2.23 Lead Sulfide - Available in D. 655

NOTE: If a vehicle is needed for any of the above compounds, contact R. Kollmansberger, D. [illegible].

3.3 Fixture Materials

3.3.1 301 stainless steel tubing thickness X 5' long. 2 1/2" O.D. X .065 wall
3 1/2" " " " "
2.0" " " " "

3.3.2 301 S.S. sheet MIL-S-~~6721~~ .090" X 24" X 36"

3.3.3 316 S.S. wire (QQ-W-423) .030" dia. X 15'

NOTE: If 301 stainless steel is not available, use 302, 304, or 321 stainless.

4. PROCEDURE:

4.1 Specimen Preparation

4.1.1 Cut each bar into 1.25" lengths and drill a 1/8" hole near one end.

4.1.2 Heat treat the alloys of paragraph 3.1 according to the following procedure. All heat treats shall be done in calibrated furnaces.

a.	Inconel X	MAC P.S. 15924
b.	A-286	MAC P.S. 15928
c.	Rene' 41	MAC P.S. 15602
d.	L-605	No heat treat req'd.
e.	HastElloy X	No heat treat req'd.
f.	310 S.S.	No heat treat req'd.
g.	4130 Steel	MAC P.S. 15013

4.1.3 Machine all specimens to remove scale.

4.1.4 Fabricate test fixture per Figure I. (24 req'd.)

4.2 Testing

4.2.1 1000°F exposure

a. Place one specimen of each alloy in every container. Each container will then have seven specimens for this exposure temperature.

b. Add the 23 antiseizing compounds to their individual containers and identify. Make sure that the alloy specimens are not exposed to air. The one remaining container and its specimens will be exposed to temperature without any compound.

c. ~~Weld shut, and~~ Expose to 1000°F for 10 hrs. Then air cool. Remove specimens from the container.

4.2.2 1800°F exposure

(For this temperature, the 4130 specimens are omitted.) With a new group of specimens, repeat procedure of 4.2.1 (a) through 4.2.1 (c) except that the temperature is now 1800°F. Expose for 10 hrs., then air cool. If at all possible, use the same containers that were used at 1000°F.

4.2.3 Prepare transvere metallographic specimens of all specimens.

NOTE: The first 9 compounds to be tested are:

Molykote X-106M	Lead Sulfide
Silica	Boric Oxide
Lead Monoxide	Electrofilm 1000
~~Tungsten Disulfide~~	~~CBS Process CID-5940~~
Calicum Fluoride	

After these, the order of testing is not important.

5. DATA REQUIRED:

5.1 Photomicrographs at 250X's for each specimen tested.

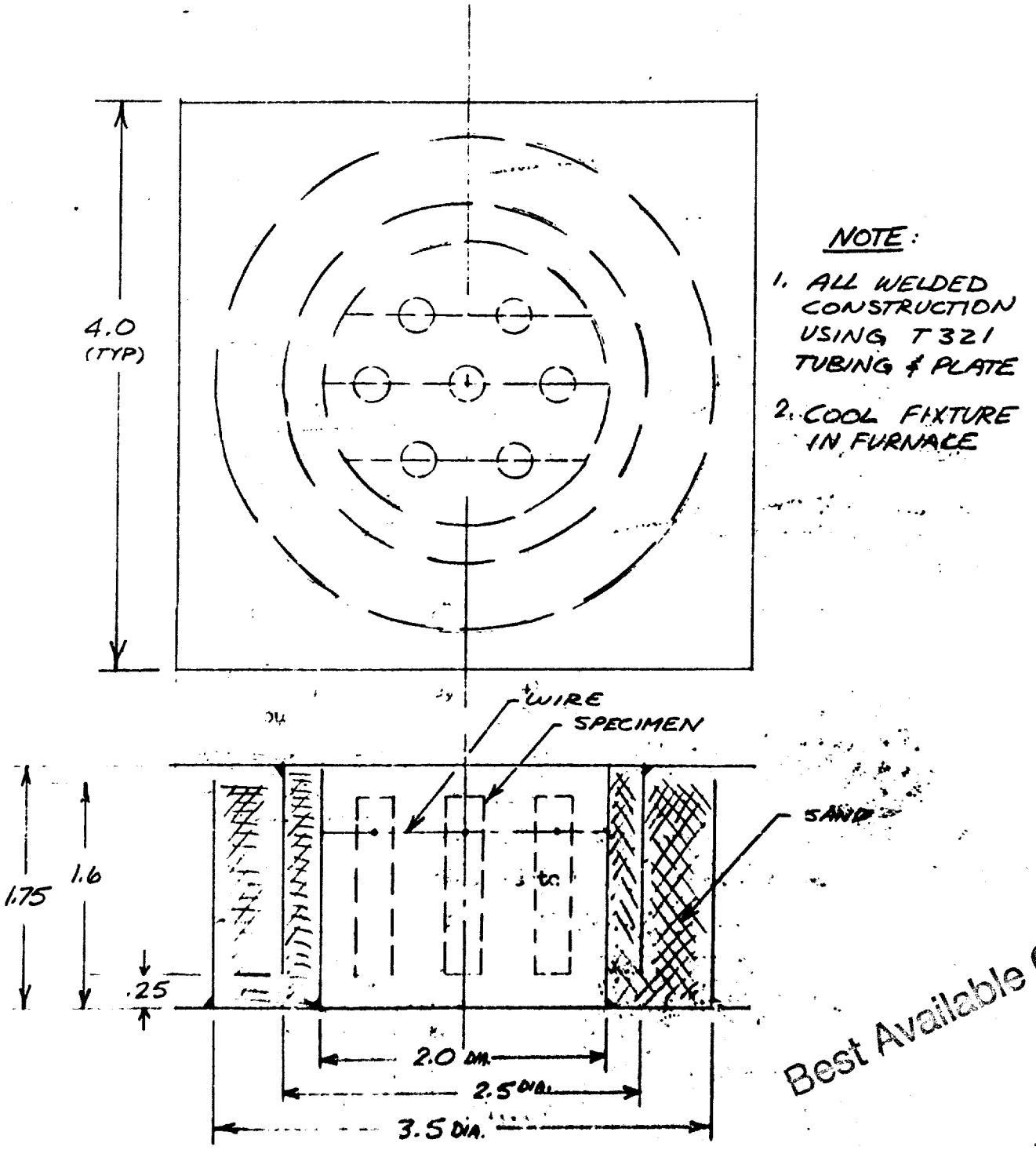

FIG. I